

BBC

SOLVING THE MYSTERY OF WHY WE SLEEP

# Science Focus

A SEA CHANGE IS COMING

**Life's building blocks  
IN INTERSTELLAR SPACE**

**What if we all  
QUIT FAST FASHION?**

**How dangerous is  
ANTIBIOTIC RESISTANCE?**

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REPORT

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**Eugenics**

Dealing with science's  
greatest scandal

**Extinction Rebellion**

How peaceful protests can  
inspire meaningful change

**Whales**

Why do so many  
beach on our shores?

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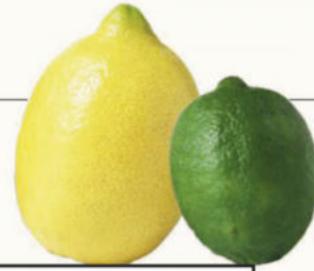
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Why are lemons yellow and limes green? → p95



## CONTRIBUTORS



### HELEN SCALES

Helen, a marine biologist, science writer and broadcaster, takes a look at some of the pioneering projects that might just save the oceans. → p48



### ADAM PEARSON

Is human selective breeding a thing of the past, or is it making a comeback through prenatal genetic testing? Disability activist Adam talks about the terrifying history, and future, of eugenics. → p60



### GINNY SMITH

Ginny presents the British Psychological Society's podcast *PsyCrunch*, which looks at how psychology research makes a difference to everyday life. This issue, we've asked her to investigate what keeps sleep scientists up at night. → p78



### HAYLEY BENNETT

To kick off our new *What if...* series, science writer Hayley imagines a world in which fashion no longer exists. → p83

# FROM THE EDITOR



In September, the IPCC released its report on the state of our oceans. Compiled from thousands of studies, it made grim reading. Together with the cryosphere, the blue parts of our planet have been absorbing most of the heat and CO<sub>2</sub> we've been generating since the Industrial Revolution. And we're set to witness the consequences.

Overfishing, rising sea levels and acidic water conditions have led to empty fishing nets, receding shorelines and barren reefs that are ruining livelihoods that depend on the coast. But the report made one thing clear: there's no escaping the consequences of an ocean that's getting hotter. Warmer seas will whip up more floods, cyclones and hurricanes. And extreme weather patterns are likely to leave droughts in their wake. Fortunately, there is something to be optimistic about. If governments can limit the CO<sub>2</sub> we create, the worst consequences can be avoided. And if the scientists on p48 have anything to do about it, there might still be a blue planet for the next generation to enjoy.

Plus, we've listened to your feedback and have brought back the *Innovations* section (p42) and revamped *Radar* (p98). Let us know what you think!

*Daniel Bennett*

**Daniel Bennett, Editor**

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## ON THE BBC THIS MONTH...

### The Life Scientific

Jim Al-Khalili chats to neuroscientist and DeepMind co-founder, Demis Hassabis (pictured), for the 200th episode of *The Life Scientific*. 5 November, BBC Radio 4

### Seven Worlds, One Planet

Sir David Attenborough returns with a new series on the seven continents that make up planet Earth. 27 October, BBC One (Available on iPlayer)

### All In The Mind

Dr Adam Kay, author of *This Is Going to Hurt*, and occupation health psychologist Prof Gail Kinman, discuss what makes a workplace stressful and what can be done about it, with presenter Claudia Hammond (pictured). BBC Radio 4 (Check *Radio Times* for details)

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A newly discovered electric eel emits the biggest electrical punch of any animal.

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### HOW WE CAN SAVE THE OCEANS

Meet the innovators who are working to safeguard our seas.



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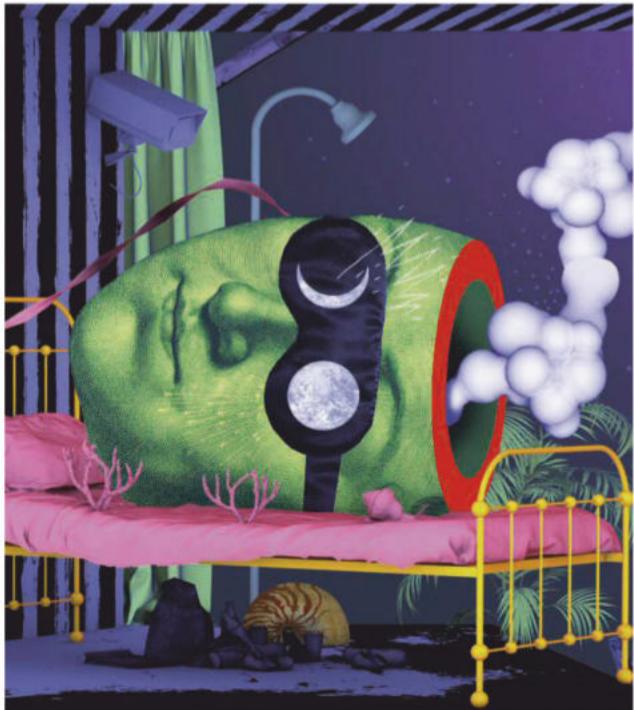
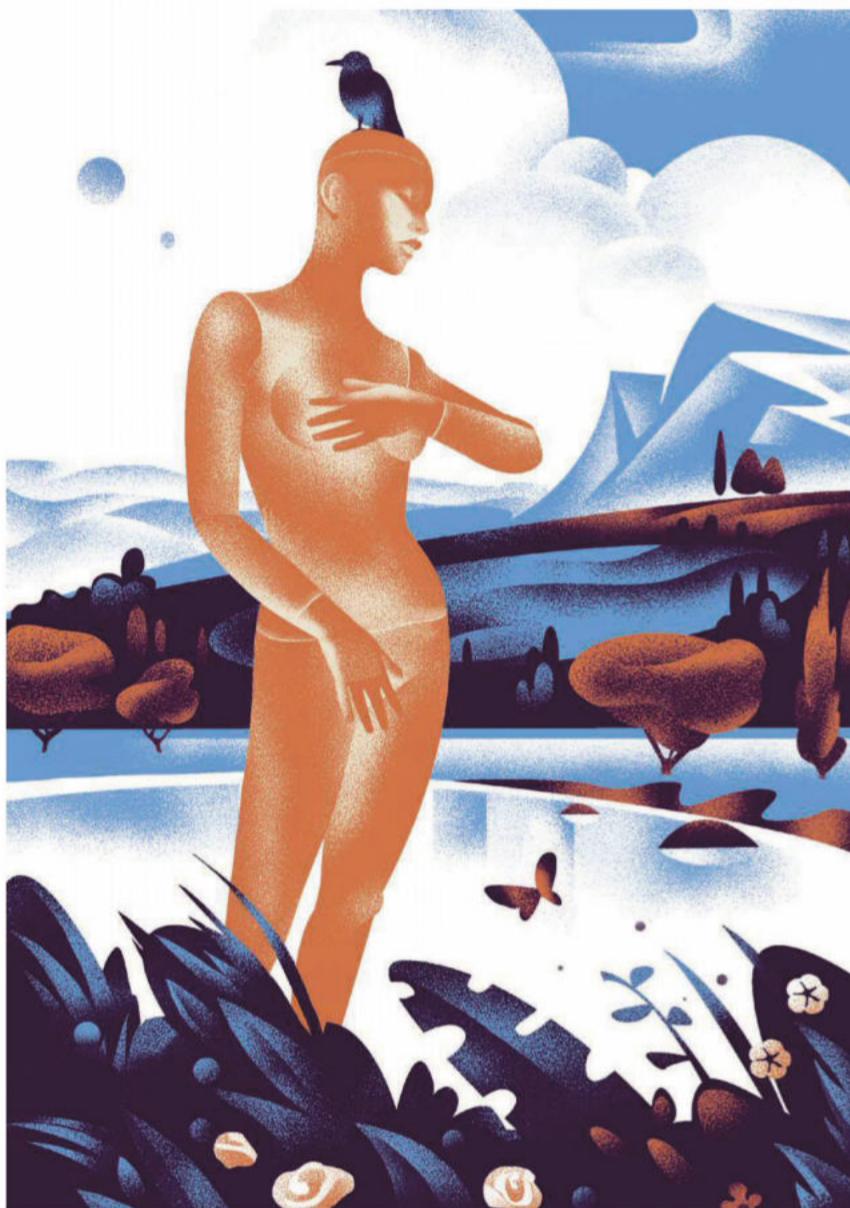
We talk to Adam Pearson about his new BBC series on eugenics.

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Scientists aren't sure why we need sleep, but we do! And that's just one of many things we don't yet understand about our nightly kip...

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The environmental impact of the fashion industry is huge. Would we better off if we just ditched fashion entirely?

**78 THE MYSTERIES OF SLEEP****83 WHAT IF... WE JUST FORGOT ABOUT FASHION?****60 INTERVIEW: ADAM PEARSON**

“Nothing’s the end of the world. I crushed it and my kids are going to crush it”

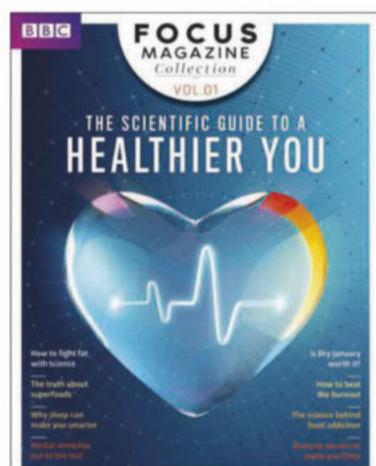
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In this special edition, brought to you by the team at *BBC Science Focus*, we investigate how to fight fat with science, we also discover the truth about superfoods, find out why sleep can make you smarter, and ask whether Dry January is worth it.

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## EYE OPENER

# Velocity raptors

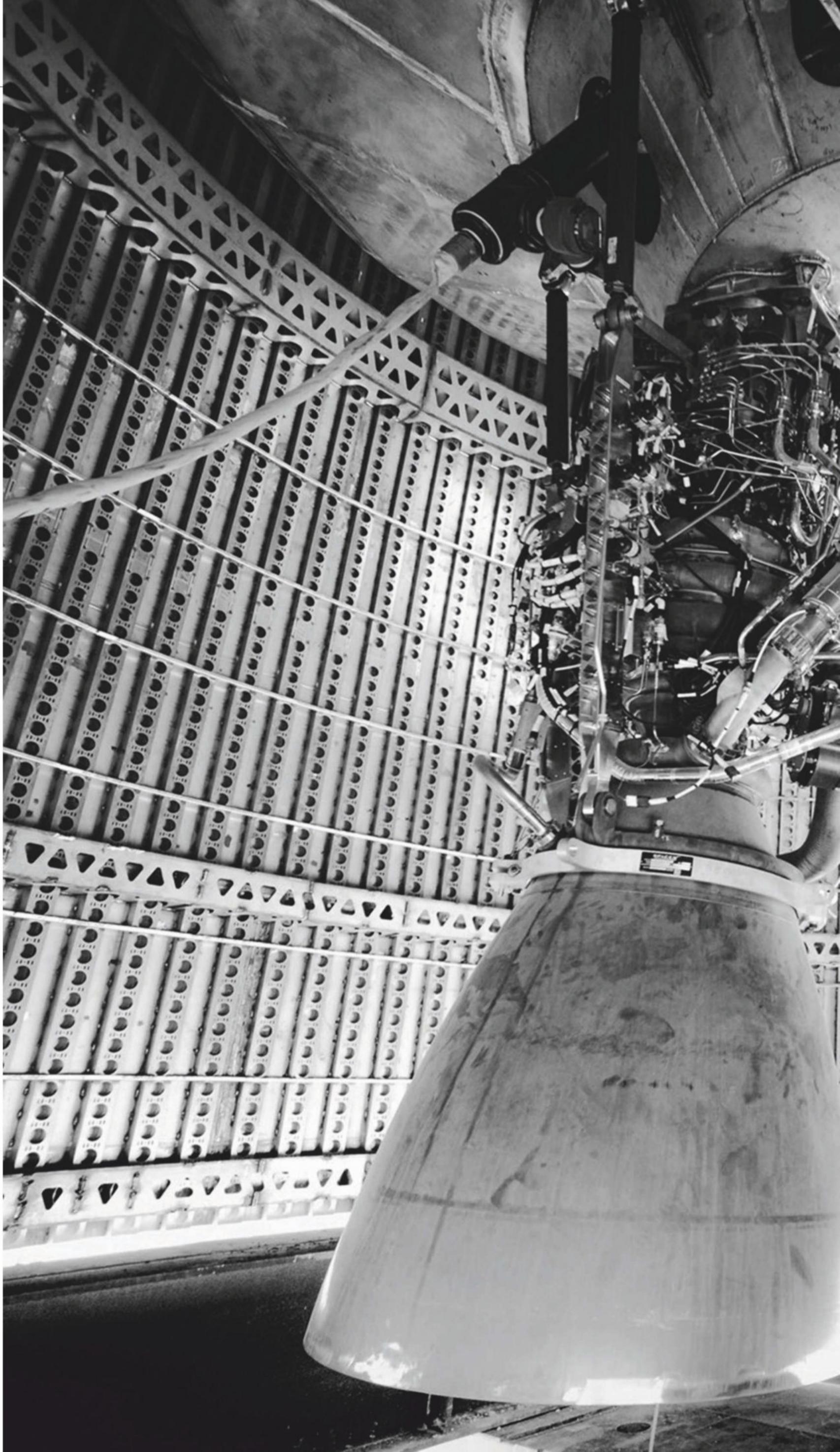
**TEXAS, USA**

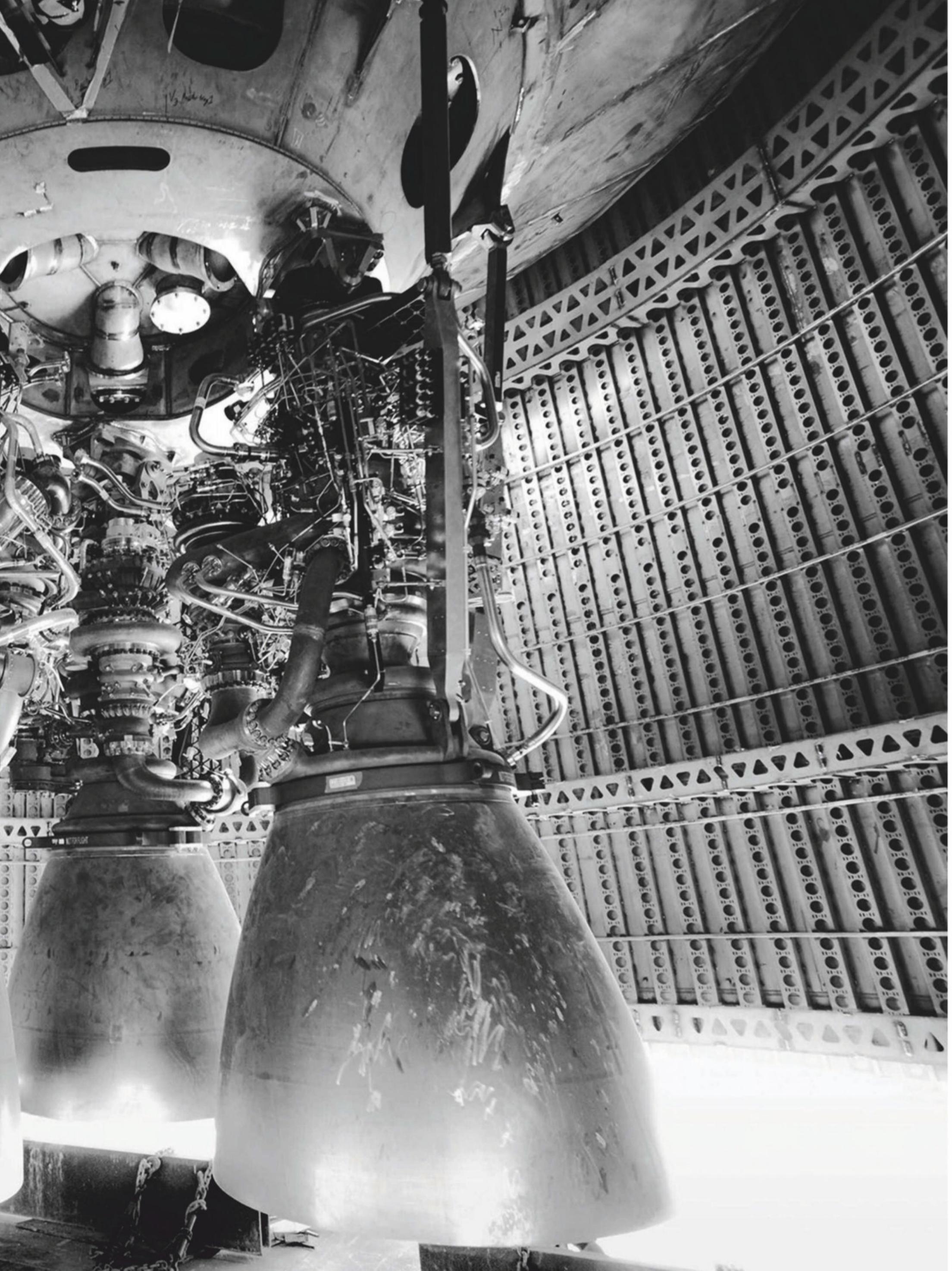
Three of SpaceX's Raptor rockets undergo testing at the company's build and launch facility in Cameron County, Texas. The engines will power the next-generation Starship spacecraft, which is due to undertake its first orbital flight in 2020. Commercial operations – from launching satellites into orbit to refuelling other craft such as the ISS – will then commence in 2021.

In total, 43 Raptor engines will power Starship: six in the Starship spacecraft itself, and 37 more in the Super Heavy rocket which blasts the entire payload into space. Both parts of the craft are reusable: Starship measures 9x50m, has a payload capacity of 100 tonnes and can carry cargo, passengers or fuel, while Super Heavy measures 9m x68m, has a maximum lift-off capacity of 3,680 tonnes and, after launch, will return to the launch site and land upright on its six legs.

SPACEX

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## EYE OPENER

# Spawny devil

AIN, FRANCE

This picture shows a male member of the species *Bufo bufo* – the common toad – sitting at the bottom of a lake in the French Alps, surrounded by numerous strings of toadspawn.

Common toads migrate towards their favoured breeding sites once out of hibernation. Scientists do not yet know why certain waters are favoured for this purpose while seemingly identical sites nearby are rejected, but 80 per cent of males return to the site where they themselves were spawned.

Once at the site, males will sit and wait for a female to come along. Competition for mates is fierce, and while this mostly takes the form of croaking contests, fights do occur – as do 'mating balls', where multiple males all attempt to mount a single female at once.

If a mate is found, the male will remain mounted on top of her for several days, individually fertilising the long strings of eggs as she lays them.

REMI MASSON/NATUREPL.COM

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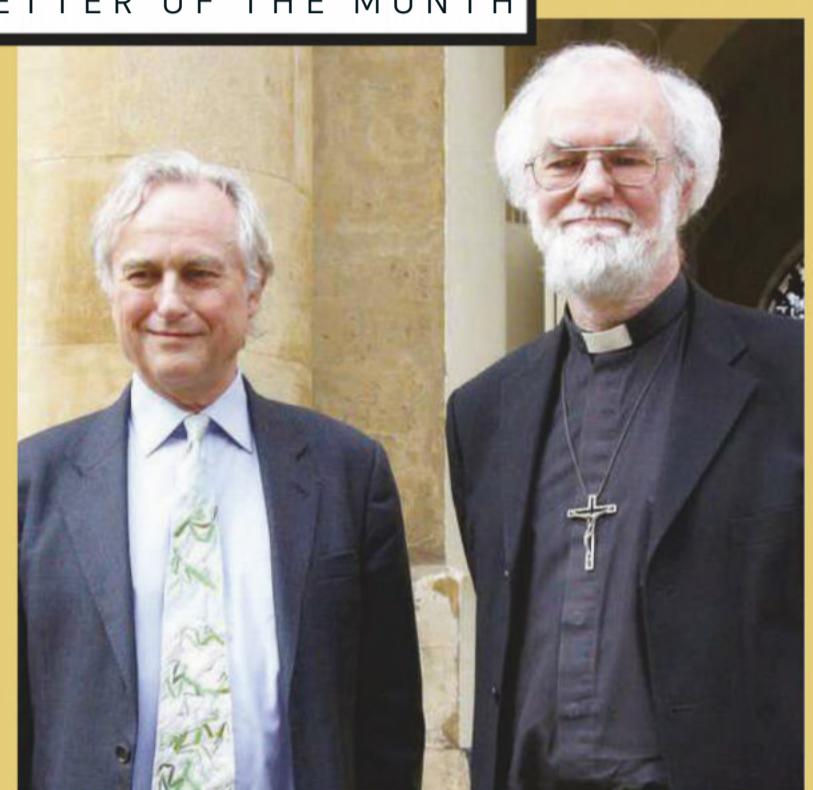
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# CONVERSATION

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND BBC SCIENCE FOCUS

## LETTER OF THE MONTH



### Belief and science

I enjoyed reading the article by Richard Dawkins (September, p62). I am a Christian who fully accepts the evidence for evolution. I am saddened by the number of church leaders I meet who have little understanding of evolution or else a misunderstanding of

evolution, a problem cited by Dawkins in his article.

My advice to both church leaders and Dawkins would be the same: expand your reading list and your debating circles to gain an understanding of the other camp's evidence.

**Susan Bremner, Scottish Borders**

### WRITE IN AND WIN!

The writer of next issue's *Letter Of The Month* wins a bundle of **wildlife photography books** courtesy of the Natural History Museum. The books – two 'coffee table' collections, plus a beautifully illustrated desk diary – all feature winning photos from the Wildlife Photographer of the Year

competition, and will give hours of pleasure to anyone with a love of wildlife.

[nhm.ac.uk](http://nhm.ac.uk)



### More research needed

Regarding electroconvulsive therapy (September, p68), my mother was a psychiatric nurse, involved with ECT procedures in the 1950s to 1980s. In the early years she found the process appalling – she felt doctors behaved as if they had a new zap gun toy and used any excuse to employ it – but over the years she modified her opinion. Treatments seemed to be more civilised and she saw some almost miraculous cures, but she was never fully at ease with the process.

Personally, it worries me that a treatment is used without really understanding how it works... but we will never find out how it works without further research.

**Geoff Dunwell, Maidenhead**

### Every little helps

Amidst all the ongoing reports of environmental damage and global warming, your highlighting of Earth Overshoot Day (August, p20) provides another excellent way to focus minds on taking action that will help. While it is natural for people to ignore or minimise threats, it is increasingly apparent that humanity is reacting too slowly to all of this.

**Patrick Forsyth, via email**

### Keep walking!

I've just received your September issue, and was intrigued when reading: 'Walking past a smorgasbord of fast food outlets along your commute could make you fatter' (p18). Surely walking past them is okay? It's only when you go in that the problems start!

**Peter Wright, via email**

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## TOP TWEETS

**Twitter users responded to the electroconvulsive therapy article in our September issue**

### @ISRpsychologist

ECT is potentially life changing for many people in severe depressed states, but with newer treatments such as TMS [transcranial magnetic stimulation] offering similar results with fewer side effects, perhaps cash injections to alternative treatments is more beneficial? I don't think ECT should be written off so quickly.

### @S08Allan

I fail to see how inducing a seizure which causes memory problems does not violate the principle 'First, do no harm'.

### @PsychRecovery

Anyone who says ECT 'saves lives' never studied neuropathology.



**"I DON'T THINK ANYONE HAS THE RIGHT TO SAY WHAT GENES ARE AND ARE NOT GOOD, PARTICULARLY WHEN IT COMES TO DISABILITY"**

ADAM PEARSON, p60

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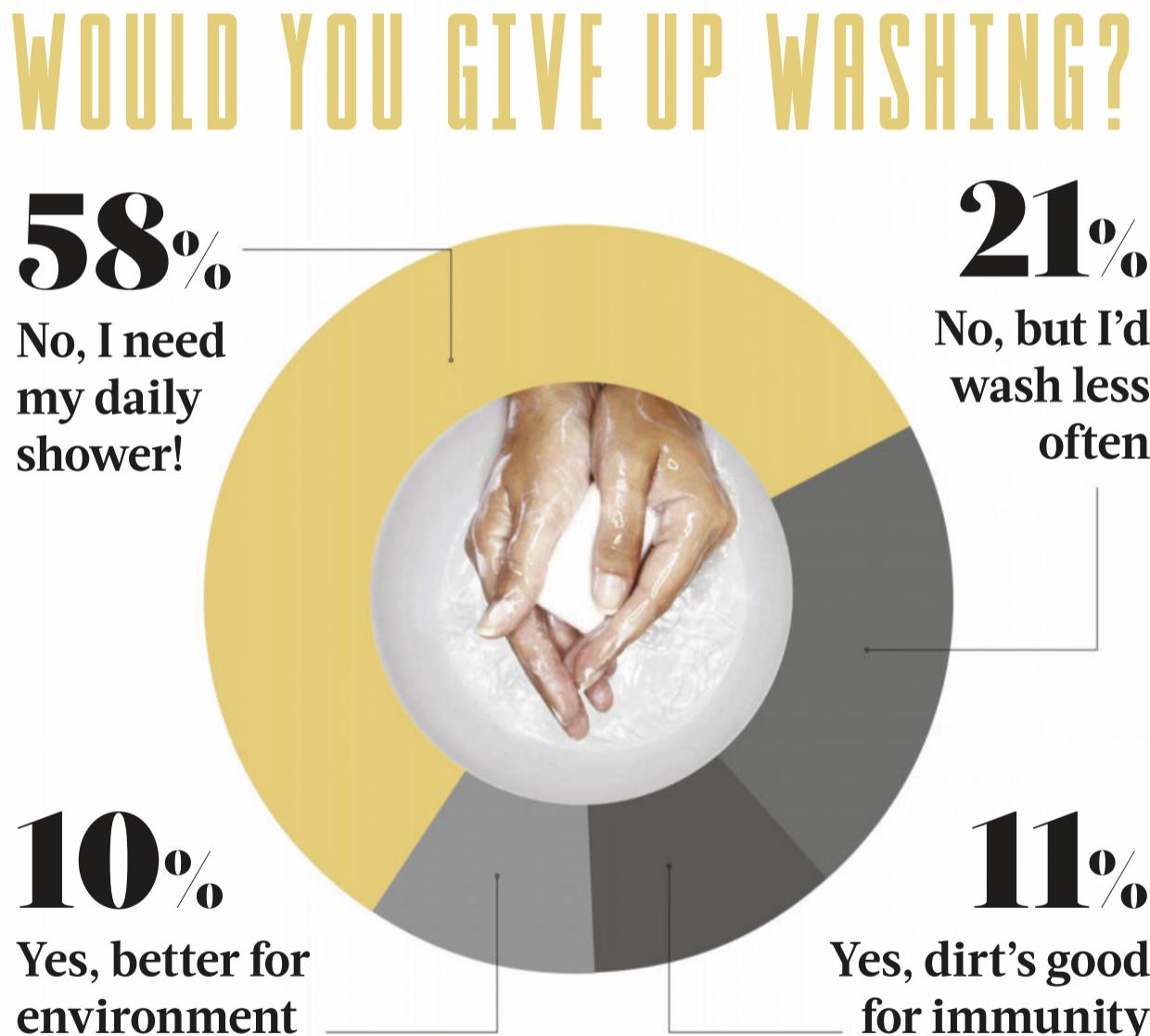
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## READERS' BUZZ

*Your views on the burning science topics of the month*

**In our Reality Check in the October issue, we discussed whether there was such a thing as being 'too clean'. We then asked BBC Science Focus followers on Twitter:**



**Amy** I get some funny looks when I say I don't shower every day, but if I did I'd never have the energy to do anything else!

**Hana** I need a hot shower every morning or my lungs and sinuses function even less.

**Alex** Showering every day can be bad for your skin if you have dermatitis or other dryness problems. People should learn to mind their own business!





## GOT MILK?

Bronze Age baby bottles discovered **p18**

## LIFE EXPECTANCY

How where you live affects how long you live for **p20**

## CLIMATE CHANGE

UN summit proves ineffective, say critics **p22**

## MEET THE FAMILY

What did the Denisovans actually look like? **p24**

# DISCOVERIES

## BUILDING BLOCKS OF LIFE COULD HAVE FORMED IN INTERSTELLAR CLOUDS

Chemical compounds called nucleobases, the essential building blocks that make up DNA, have been detected for the first time in a lab-based simulation designed to mimic the gaseous clouds that are found lingering in the vast areas of space between stars. The discovery brings us closer to understanding the origins of life on Earth, the researchers say.

"This result could be key to unravelling fundamental questions for humankind, such as what organic compounds existed during the formation of the Solar System and how they contributed to the birth of life on Earth," said Dr Yasuhiro Oba of Hokkaido. ☀

All the elements for building DNA have now been 'found' in interstellar clouds

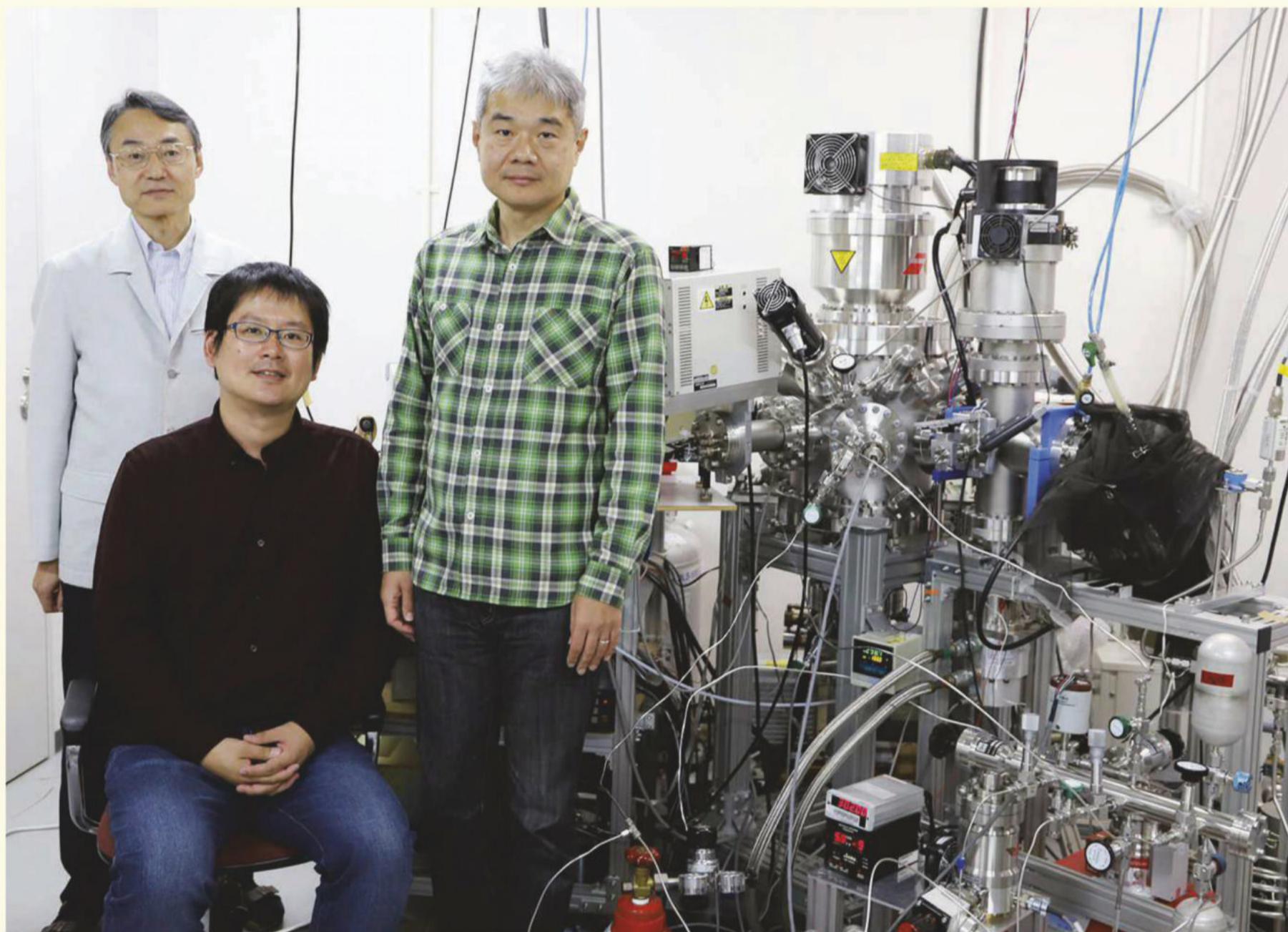
NASA, ENVER-HIRSCH/WIEN MUSEUM

**Death of the dinosaurs** New insights into ancient mass extinction **p18** **Bugging out** Germany's plan to boost insect numbers **p23**  
**Oceans in crisis** What does the new IPCC report tell us? **p28**

## News in brief

### VEGAN DIET MAY BOOST FRIENDLY GUT BACTERIA

Certain types of bacteria in our guts play an important role in maintaining a healthy weight. Now, researchers in Washington have found that switching to a vegan diet can help to boost these 'friendly' bacteria and encourage weight loss. The study involved 147 people, half of whom switched to a low-fat vegan diet. After 16 weeks, those following the vegan diet had, on average, 4.8 per cent more *Faecalibacterium prausnitzii* bacteria in their guts, and had lost an average of 5.8kg in weight.



Dr Yasuhiro Oba and his team found the building blocks of life in simulated deep space conditions

► University's Institute of Low Temperature Science, leader of the research team that made the discovery.

The basic structural unit of DNA is called a nucleotide and is composed of a nucleobase, a sugar, and a phosphate. Previous studies mimicking the conditions expected in interstellar molecular clouds have detected the presence of sugar and phosphate, but never nucleobases.

To make the discovery, the team set up a simulation of an interstellar molecule cloud by pumping a gaseous mixture of water, carbon monoxide, ammonia into a vacuum chamber

filled with simulation cosmic dust and cooling it to -263°C. Next, they shone a pair of specially designed ultraviolet lamps into the chamber to kick-start chemical reactions. This led to an icy film forming on the surface of the dust.

They then warmed this substance up to room temperature analysed its chemical composition using a high-resolution mass spectrometer. In this way, They were able to identify the presence of several nucleobases including cytosine, thymine and adenine – three of the four bases that make up all DNA. They also identified several amino acids, which are the

building blocks of proteins, another key element for the formation of life.

The team suspects that past experiments simulating interstellar molecular cloud environments would in fact also have produced nucleobases, but that the analytical tools available at the time were not sensitive enough to detect them in complex mixtures.

"Our findings suggest that the processes we reproduced could lead to the formation of the molecular precursors of life," said Oba. "The results could improve our understanding of the early stages of chemical evolution in space."

## LEARNING TO READ SHARPENS THE BRAIN'S VISUAL CAPABILITIES

As we learn to read, a brain region known as the 'visual word form area' (VWFA) becomes sensitive to the letters and characters that make up written language. Now, a study at the University of Zurich has discovered that readers' brains are more sensitive to visual information in general. The team used an fMRI scanner to study the brains of more than 90 adults from northern

India with varying degrees of literacy, ranging from people unable to read to skilled readers. While in the scanner, participants saw sentences, letters and other random images such as faces. The brains of those with more advanced reading skills were activated more intensely by all images regardless of content, indicating an increased sensitivity to visual stimuli.

## PSYCHOLOGY

# How psychopaths control their 'dark impulses'

Why do some psychopaths end up in jail, while others hold down lucrative careers? New research suggests that the answer lies in a region of the brain that's linked to self-regulation.

Psychopathy is a personality disorder that's characterised by callousness, impulsiveness, dishonesty, a lack of empathy, and superficial charm. It's estimated that around 1 per cent of the general population would meet the clinical criteria for psychopathy. Contrary to popular belief, though, only a minority of psychopaths are violent.

Psychologists at Virginia Commonwealth University and the University of Kentucky wanted to find out how some psychopaths are successfully able to control their 'dark', antisocial impulses, maintaining careers and even intimate relationships.



The researchers recruited people from two different populations: adults in long-term romantic relationships, and undergraduate students. Any people found to have psychopathic tendencies in these groups would be deemed 'successful psychopaths'. The participants first completed questionnaires to assess their level of psychopathy, and then had their brains scanned in high-resolution using magnetic resonance imaging (MRI).

The researchers found that participants with higher levels of psychopathy had a greater density of grey matter in their 'ventrolateral prefrontal cortex' – a region of the brain that's known to be involved in self-regulatory processes, such as the damping down of impulsive emotions like fear and anger.

"Our findings [...] suggest that these individuals may have a greater capacity for self-control," said Emily Lasko from Virginia Commonwealth University, who led the study.

Understanding the neurological differences between psychopaths who manage to control their antisocial tendencies and those who don't could point the way to new treatments.

"If we are able to identify biomarkers of psychopathy and, importantly, factors that could be informative in determining an individual's potential for violent behaviour and potential for rehabilitation, then we will be better equipped to develop effective intervention and treatment strategies," said Lasko.

## They did what?

### Rats taught to play hide and seek

#### WHAT DID THEY DO?

Annika Reinhold, a graduate researcher at the Humboldt University of Berlin, implanted wireless electrodes into the brains of six young rats, then let them roam free in a 25m<sup>2</sup> room scattered with boxes and other obstacles suitable for hiding behind. After playing with the rats for around one month so that they became comfortable in her presence, she began hiding and encouraging them to look for her using food treats and other rewards.

#### WHAT DID THEY FIND?

The rats picked up the idea of the game quickly and seemed to enjoy it, often 'giggling' and jumping for joy as they played. Not only did all six rats quickly learn the seeking part of the game, five of them learned the hiding part too. Some of them would even remember where they had previously found the researchers and then use the same hiding places.

#### WHY DID THEY DO THAT?

Playing is an important part in the mental development of young mammals. By studying play behaviour in rats we may be able to learn more about the role it plays in the development of young humans.



**SIESTAS COULD IMPROVE CARDIOVASCULAR HEALTH**

Taking a nap once or twice a week can nearly halve your risk of heart problems, a study at the University Hospital of Lausanne in Switzerland has found. The researchers monitored 3,462 Swiss residents for five years and found that those who took the occasional nap were less likely to get a cardiovascular

disease such as a stroke. More research is needed to determine exactly how 40 winks lowers the risk of heart problems. However, it is unlikely to be solely down to nappers catching up on missed sleep, as the effect was also seen in those who napped despite getting a full night's slumber.



# Trending

**YOUR GUIDE TO WHO'S SAYING  
WHAT ABOUT THE HOTTEST TOPICS  
IN THE WORLD RIGHT NOW**

**#pinemartens**

A group of 18 pine martens have been released in a secret location in the Forest of Dean in an attempt to reintroduce the charismatic animals to England and Wales.

**Stuart Edmunds**

@PinemartensUK

Good to hear that the first few #pinemarten have been successfully released in the #ForestofDean. #Cameratraps in south #Shropshire are recording #pinemartens roaming around still so hopefully the two populations will eventually meet each other in the not too distant future...

**People's Trust for Endangered Species**

@PTES

Great news that our partners, @vincentwildlife have released #pinemartens back to England. We investigated the feasibility of bringing these charismatic creatures back to England and are delighted that they're finally back in our forests!

**#Fatberg**

Scientists at the University of Exeter have performed an 'autopsy' on the 64-metre fatberg found under the Esplanade in Sidmouth at the end of last year. It was mostly made up of cooking oil, wet wipes and sanitary pads, they say.

**Leon Collyer**

@chewdafat

If you ever complain about how crap your job is, at least you're not one of the poor sods who had to 'perform an autopsy' on that 64m fatberg

**Richard Tennant**

@richardktennan

Was certainly one of the more interesting samples we've worked with! Thanks to @UniofExeterNews for their great work documenting our progress over the past 8 months



KEEP IN TOUCH



@SCIENCEFOCUS

**#ADHDawareness**

October marked ADHD Awareness month, an initiative intended to increase the visibility of this neurodevelopmental disorder.

**Dr Carla M. Shuman**

@DrCarlaMShuman

Let's raise #ADHDawareness by educating others that #ADHD isn't just about trouble paying attention. Difficulty with #EmotionRegulation is also common, and ADHD affects peer relationships as well as academics

**Kathryn Garforth, PhD**

@GarforthEduc

People will often joke about someone having #ADHD, but do they ever stop to think what it is really like to not be able to concentrate on something even if you really want to? #adhdawarenessmonth #adhdawareness @ADHDFoundation

**#TheOceanCleanup**

A gigantic floating device designed to clean up the island of floating rubbish in the Pacific has successfully picked up plastic for the first time.

**Boyan Slat**

@BoyanSlat

Our ocean cleanup system is now finally catching plastic, from one-ton ghost nets to tiny microplastics! Also, anyone missing a wheel?

**Dr Di Chadwell, A&P,  
Hon.C.TDNN, Ret.**

@ONELONEDOLPHIN

#ThankfulThursday let's play a new hashtag game! What are you thankful for? I'm thankful for thinkers like @BoyanSlat for tackling #TheOceanCleanup SUCCESSFULLY cleaning #PlasticPollution in our #GreatPacificGarbagePatch @TheOceanCleanup





### TEA DRINKERS

Put the kettle on! Lovers of a cuppa have healthier brains than non-tea drinkers, a study at the National University of Singapore has found. MRI scans of a group of over-60s showed that the brains of tea drinkers are more efficiently connected.

### OPTIMISTS

People with a 'glass half full' disposition are less likely to have a heart attack, researchers in New York have found. They gathered together data from 15 studies involving more than 200,000 participants and found that those with high levels of optimism were 35 per cent less likely to suffer a heart attack.

## Good month

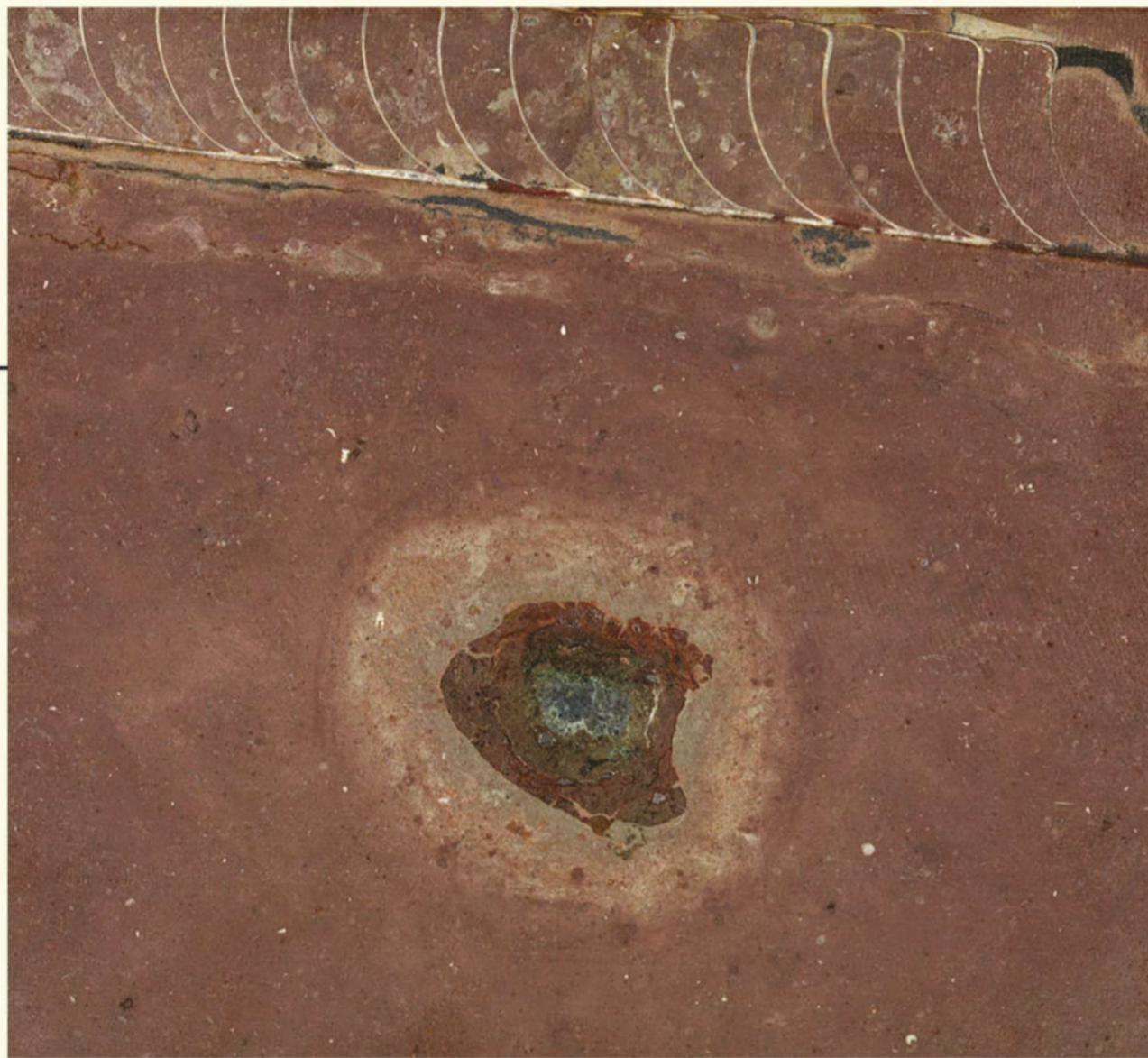
## Bad month

### POSING POLITICIANS

Striking a power pose – the Wonder Woman-esque stance touted in some quarters as a way to reduce stress levels and increase confidence – is no more effective than simply standing up straight, a review of 40 previous papers carried out at Iowa State University has found.

### CYBERBULLIES

Trolls beware! Researchers at Binghamton University have developed an AI that can identify aggression, harassment and bullying in social media posts with 90 per cent accuracy. They hope the tech will be used to flag up cyberbullies and get their accounts deleted.



This fossil meteorite was created from the same asteroid collision that led to an ice age 466 million years ago

### CLIMATE SCIENCE

## Giant asteroid collision in outer space kicked off ancient ice age

An ice age that occurred on Earth 466 million years ago may have been triggered by dust sent floating into the atmosphere by a giant asteroid collision in outer space, a study by researchers based in Sweden and the US suggests. A similar cooling effect could potentially be harnessed to tackle climate change, they say.

The team made the discovery by comparing the chemical composition of rocks dating back to a known ice age 466 million years ago, to that of tiny meteorites discovered in Antarctica. They were looking for elements that rarely appear in Earth rocks, and for isotopes – alternate forms of atoms that have differing numbers of neutrons – that show hallmarks of coming from outer space. For instance, some helium atoms that are shot out of the Sun and into space are missing a neutron. The presence of these special helium isotopes, along with rare metals often

found in asteroids, proves that the dust originated from space.

The researchers found that tens of thousands more particles than usual fell to Earth from space over a period of around two million years – a period that perfectly corresponds with the onset of the known ice age. This extra dust in the atmosphere helps to explain why the ice age occurred: by filtering out sunlight, the dust would have caused global cooling. A similar effect could potentially be used to cool the Earth in an attempt to reverse the effects of climate change.

"Our results show for the first time that such dust, at times, has cooled Earth dramatically," said the study's lead author Prof Birger Schmitz of Sweden's Lund University. "Our studies can give a more detailed, empirical-based understanding of how this works, and this in turn can be used to evaluate if model simulations are realistic."

## ANCIENT HUMANS FED THEIR BABIES ANIMAL MILK

Scientists from the University of Bristol have found the earliest evidence of baby bottles that were used to feed animal milk to infants. The vessels, which are small with a narrow spout, date back to the Bronze Age (1200–800 BC) and Iron Age (800–450 BC) and were discovered in ancient children's graves in Bavaria. By using chemical and isotopic analysis to study residues

on the bottles, the researchers established that they once contained the milk from domestic cattle, sheep or goats. This study offers important information about breastfeeding and weaning practices during prehistoric times, and the researchers now want to study similar vessels from other ancient cultures to see if they served the same purpose.



## In numbers

**1.7 MILLION YEARS**

The age of a rhino tooth that Danish researchers obtained a sample of DNA from. It's the oldest genetic information ever collected.

**201 km**

The diameter of Loki, a giant volcano on Jupiter's moon Io that's poised to erupt at any time.

**4.6 MILLION YEARS**

The age of the Sahara Desert, as estimated by analysing ancient dust that was blown across to the Canary Islands millions of years ago.

## PALAEONTOLOGY

# Drilling into the day the dinosaurs died

It was one of the most destructive days in the history of our planet, and now we know how it played out. Scientists have pieced together the first day of the dinosaurs' demise, by drilling into the crater that formed from the asteroid that triggered their downfall.

The asteroid, which led to the extinction of all non-avian dinosaurs, slammed into the Gulf of Mexico's Yucatán Peninsula some 66 million years ago. In 2016, a scientific drilling project by the International Ocean Discovery Program retrieved rocks from the impact site,

which is submerged offshore. Now, scientists have analysed these rocks to travel back in time to doomsday itself.

"It's an expanded record of events that we were able to recover from within ground zero," said Dr Sean Gulick, a geophysicist at the University of Texas at Austin and leader of this study. "It tells us about impact processes from an eyewitness location."

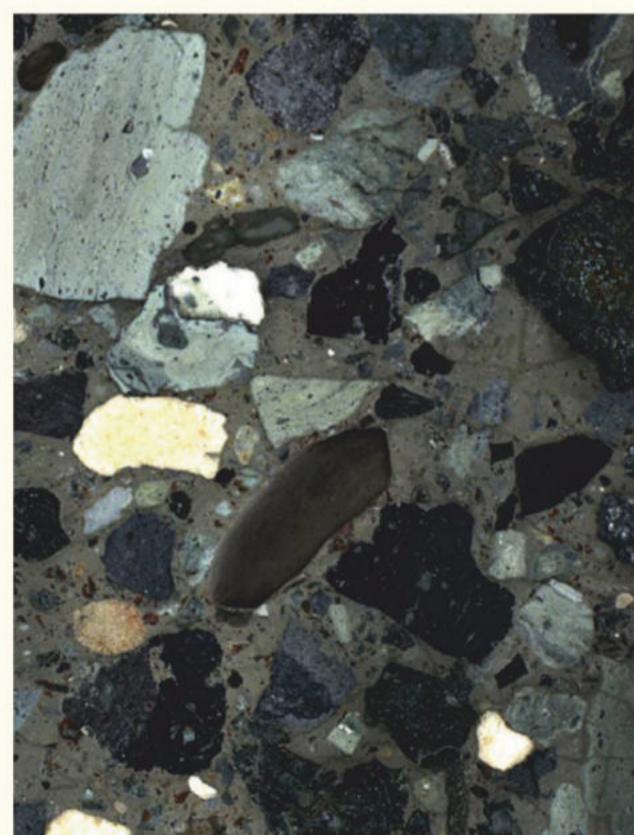
In just 24 hours following the impact, a layer of material 130m thick was deposited. This included charcoal, which provides evidence for the intense wildfires that are thought to have been ignited by the blast.

Meanwhile, the impact also triggered a huge tsunami, as evidenced by jumbles of rock and layers of sand in the core samples, which appear to have been deposited by resurging waters.

One thing conspicuously missing from the samples, though, is sulphur. Although the surrounding area is full of sulphur-rich rocks, the crater is unusually sulphur-free. This supports the idea that the asteroid impact instantly vaporised sulphurous rocks, releasing the sulphur into the atmosphere, where it lingered and reflected away the Sun's light, cooling the Earth's climate.

Although the impact had devastating effects on a regional level, it's this large-scale global cooling that's thought to be behind the dinosaurs' eventual demise, as well as that of countless other plant and animal species.

"The real killer has got to be atmospheric," said Gulick. "The only way you get a global mass extinction like this is an atmospheric effect."



Mineral deposits at the impact site reveal more about how the dinosaurs perished

Shocking stuff:  
electric eels  
were observed  
to hunt in  
packs,  
surrounding  
their prey



## ZOOLOGY

# Newly discovered electric eel packs the biggest electrical punch of any known animal

This is something to get amped up about: a team from the Smithsonian Institute has discovered a new species of electric eel that can generate an electrical shock of up to 860 volts, the strongest of any known animal.

Despite their misleading name, electric eels are actually naked-back knifefishes and are more closely related to catfish and carp than to other eel families. They can reach up to 2.5 metres in length and are the only fish capable of producing such strong electrical discharge via three electric organs. They use their powerful shocks for defence and for stunning prey.

It was previously believed that there was just one species of electric eel – *Electrophorus electricus* – but a survey of 107 specimens collected in different parts of the Amazon in Brazil, Suriname, French Guiana and Guyana, has identified two further species – *E. varii* and *E. voltai*.

The new species were identified by comparing the eels' DNA, body shape and preferred habitat, as well as by measuring the voltage of their electrical discharges. The team found that *E. voltai* produced the most powerful shocks ever measured in an animal.

"The discovery of new electric eel species in Amazonia, one of the planet's biodiversity hotspots, is suggestive of the vast amount of species that remain to be discovered in nature," said Carlos David de Santana, associate researcher at the Smithsonian Institute. "Furthermore, the region is of great interest to other scientific fields, such as medicine and biotechnology, reinforcing the need to protect and conserve it, and is important for studies involving partnerships among Brazilian researchers, and between us and groups in other countries, to explore the region's biodiversity."

## Data crunch

# LIFE EXPECTANCY AT BIRTH

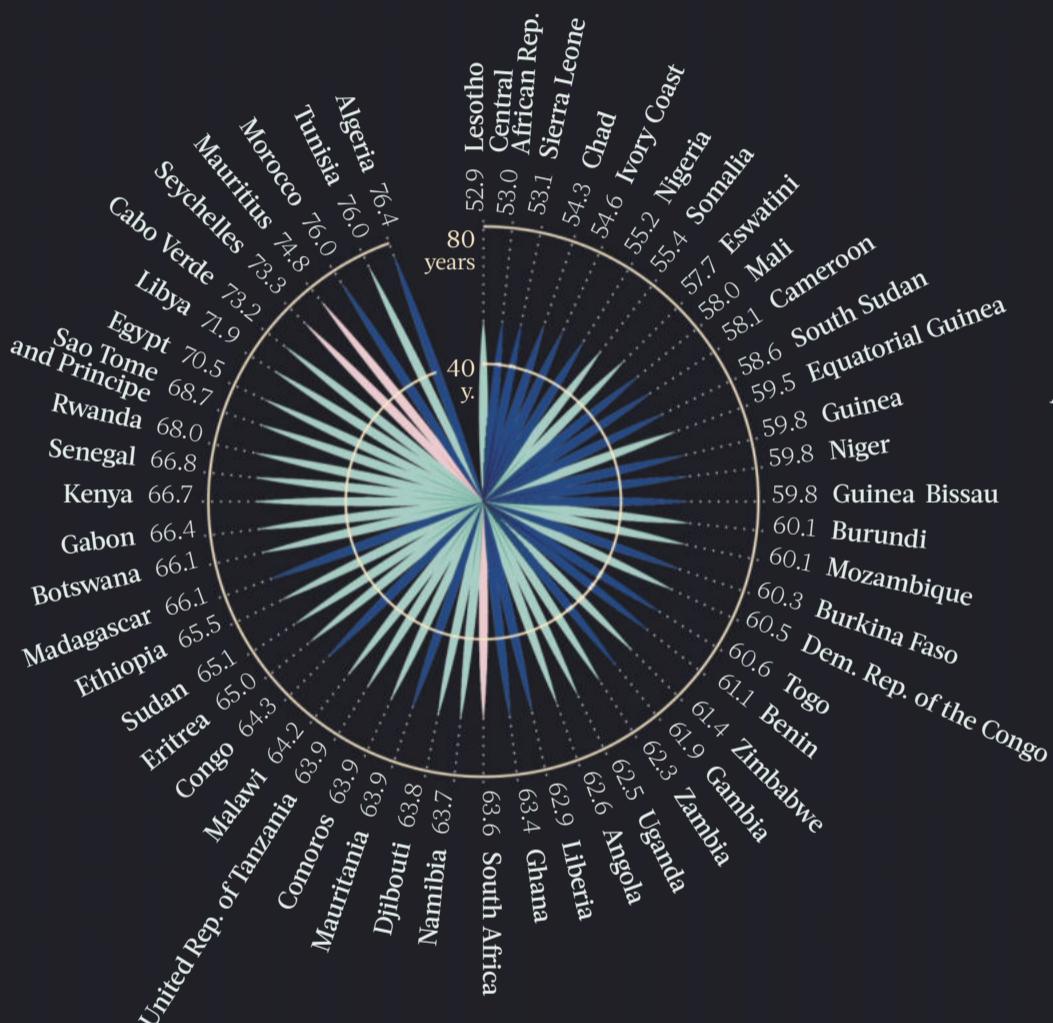
How long you live for depends on where you live. After rising steadily since records began in 1841, life expectancy in the UK has begun to fall. According to a report published this year by the Institute and Faculty of Actuaries – the body that

compiles the figures on life expectancy in the UK on behalf of the pension industry – men currently aged 65 are expected to die at 86.9 years, down six months from its previous estimate of 87.4 years, and women currently aged 65 are likely to die

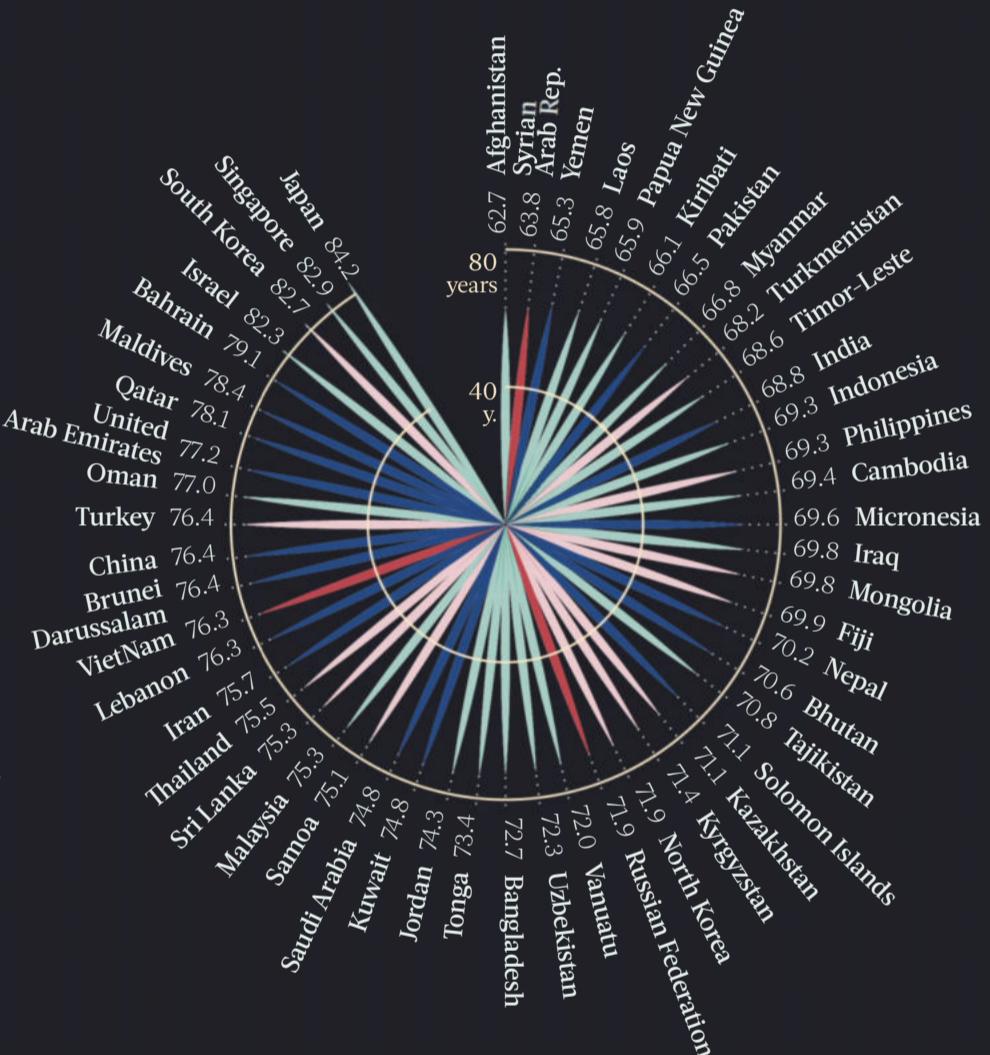
at 89.2 years, also down six months from 89.7 years. It's unclear what is responsible for the drop, but the trend of rising life expectancy began slowing down earlier this decade, with similar trends seen in the US, Australia and France.

## LIFE EXPECTANCY AT BIRTH BY COUNTRY, 2016

AFRICA



## ASIA AND PACIFIC ISLANDS



## LIFE EXPECTANCY AT BIRTH, ENGLAND AND WALES, 1841 TO 2011

— female  
— male

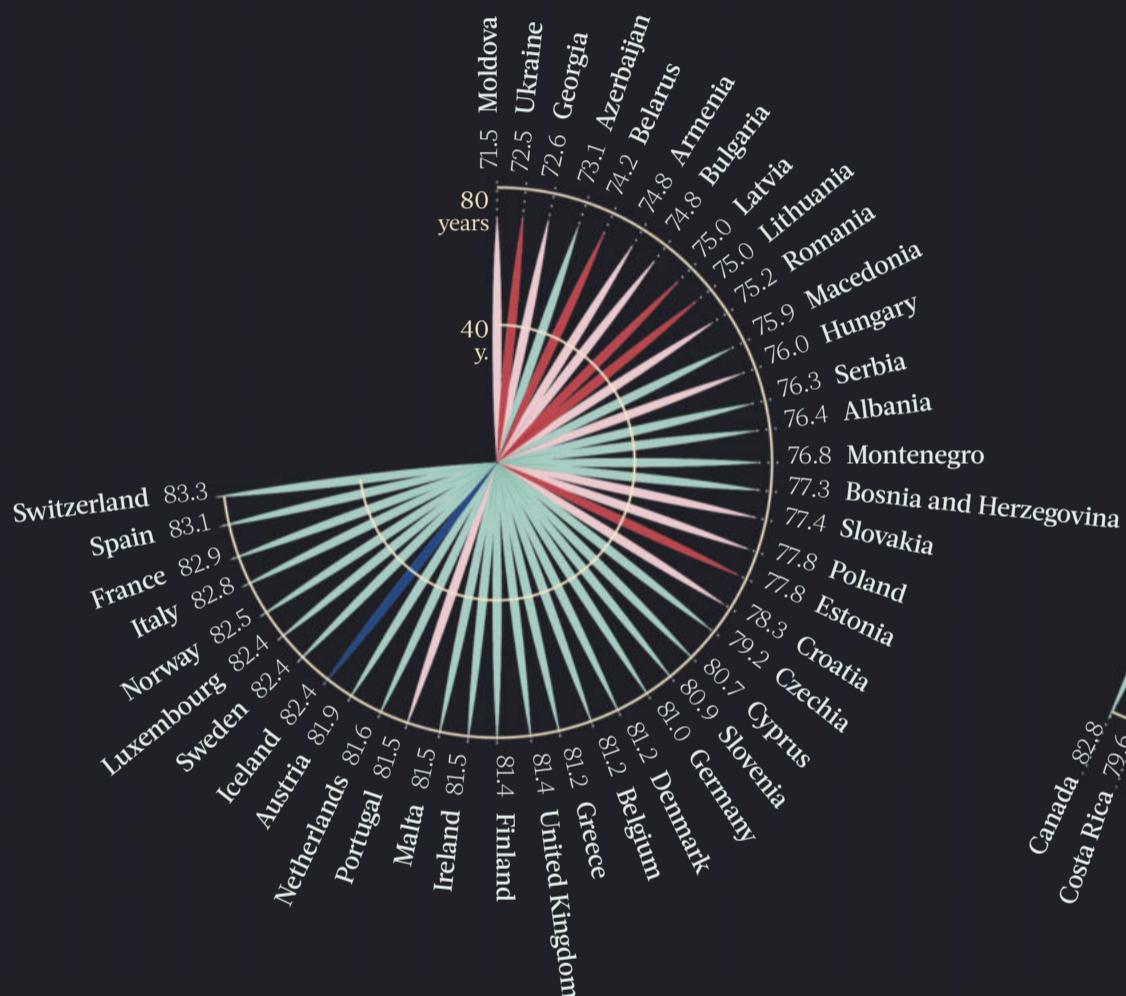
80 Country  
Line length and number = life expectancy at birth in years for both sexes

Line colour = difference between life expectancy for women and men:  
Females outlive males in all countries

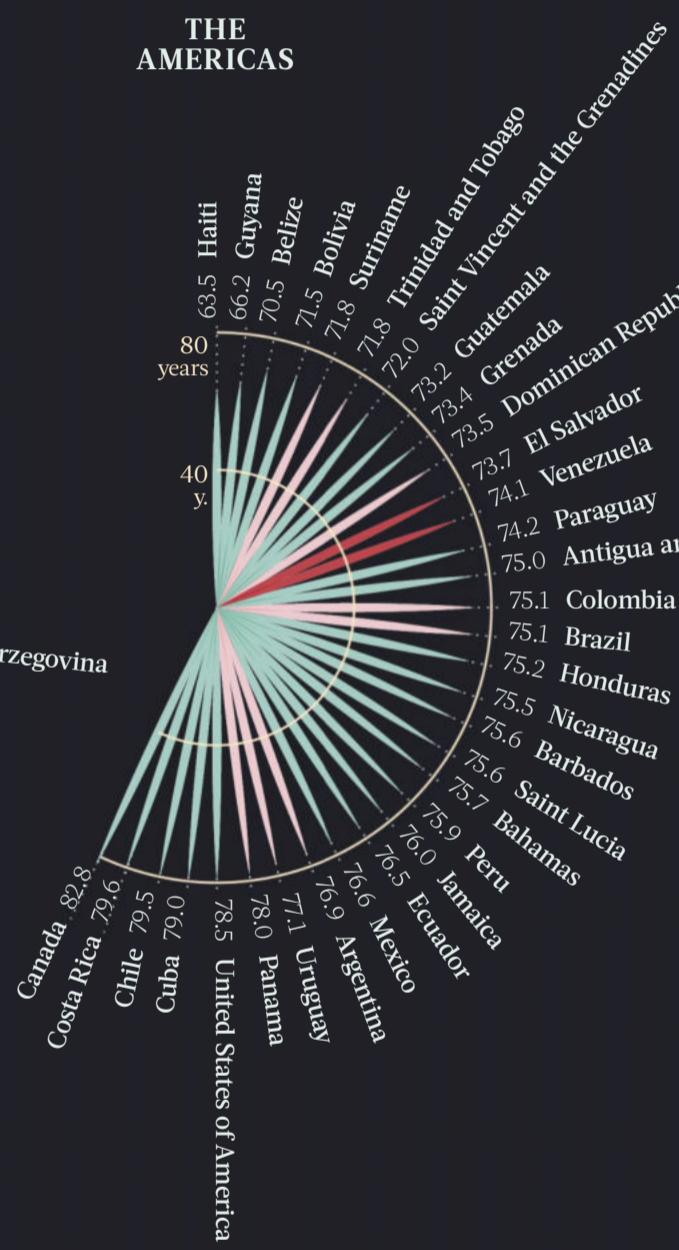
0 to 3 years  
3 to 6 years  
6 to 9 years  
9 to 12 years

Infographic by FEDERICA FRAGAPANE

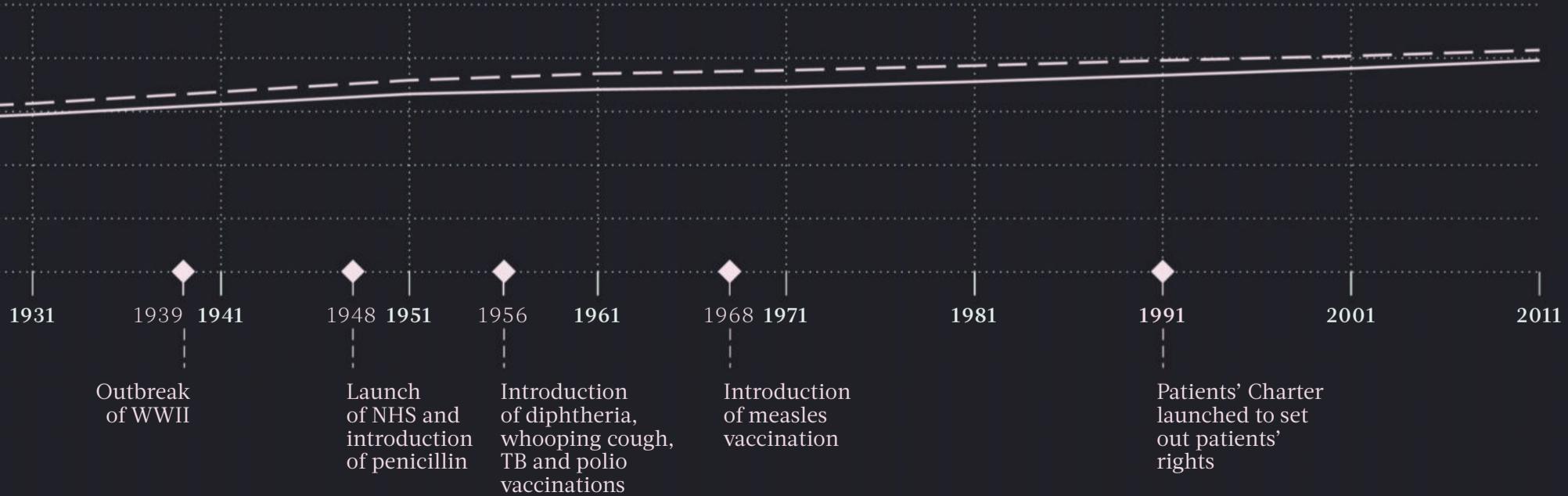
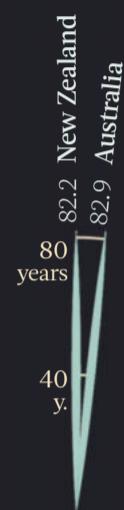
### EUROPE



### THE AMERICAS



### AUSTRALASIA



# GREEN PAPERS

The environmental stories you need to know



World leaders gathered at the UN summit

## GREENER SHIPPING

A new industry initiative has been launched to decarbonise the shipping sector. Over 70 groups have signed up to the Getting To Zero Coalition, including shipping lines, banks, ports and NGOs.

International shipping accounts for 2-3 per cent of global greenhouse gas emissions, with emissions projected to grow significantly unless action is taken. The UN's International Maritime Organization (IMO) wants to halve the sector's emissions by 2050 compared to 2008 levels, but few measures to achieve this are yet in place. The new coalition aims to help change this by putting commercially viable zero emission vessels into operation by 2030.

## ENERGY

# UN summit fails on high climate ambition

**Latest gathering disappoints those hoping for more decisive action**

A United Nations (UN) climate summit led to disappointment after the world's largest economies failed to deliver new emissions reduction pledges.

The conference, organised in September in New York by UN Secretary-General António Guterres, aimed to ramp up climate ambition, and only countries with fresh promises were allowed to speak at the summit.

"It was a kind of temperature check of where leaders are at and where countries are," said Jennifer Tollman from green thinktank E3G. "A summit like this is really a chance for leaders to step up, and to put them on the spot in the sense of 'What have you done?'"

Sixty-six countries did announce efforts towards making fresh climate pledges in 2020, when Glasgow is set

## BUG BOOST

In a bid to tackle its dramatic loss of insects, Germany has launched a major insect protection plan. Flying insect numbers in the country's nature reserves fell by over three-quarters from 1989 to 2016, according to research published in 2017.

The new "action plan for insect protection" is worth €100m per year,

including at least €25m a year towards researching insect populations. The government has also pledged to ban the weedkiller glyphosate by December 2023.

"We need more buzzing and humming again," environment minister Svenja Schulze of the Social Democratic Party (SPD) told a press conference.

to host another major summit. However, these countries' emissions only add up to around 8 per cent of the world total.

Leading countries including the US, Japan and Australia were not even invited to speak at the summit since they had nothing new to bring to the table.

Emerging economies including China and India failed to make significant new promises on climate action. However, along with the EU, they did announce plans to deliver an updated climate pledge in 2020.

The Paris Agreement, signed by 185 countries, promised to limit global temperature rise to well below 2°C and strive towards limiting it to 1.5°C. Under current individual country pledges, however, the world is on track for at least a 3°C rise – yet the science showing significant negative impacts even at 2°C of warming



**"Under current individual country pledges, the world is on track for at least a 3°C rise"**

**IT IS  
EASY  
BEING  
GREEN**



## EAT SMARTER

Fish stocks worldwide are being seriously impacted by threats including overfishing, climate change and habitat loss, meaning it's more important than ever to consider how sustainable

your seafood is, according to the Marine Conservation Society (MSC).

This might sound like a complicated task, but it needn't be. One simple thing anyone can do, says the MSC, is explore seafood other than

the UK's usual staples. Wild Atlantic salmon, for example, can easily be replaced by farmed Arctic char or rainbow trout, while prawn lovers could consider eating more sustainable rope-grown mussels instead.



## FISH IN TROUBLED WATERS

'Flying fish' robots developed by Imperial College London can launch from the water and glide up to 26 metres. They could be used to collect water samples in tricky situations such as floods.



**INSPIRED**  
**EXPIRED**



## DRASTIC PLASTIC

Replacing regular plastics with compostable ones could still harm the environment, warn an all-party parliamentary group, saying a "fundamental shift" away from all single-use packaging is needed instead.



## FOREST GLUM

Over half of Europe's native tree species – including the conker tree – are threatened with extinction, says the International Union for Conservation of Nature.



### WHY WE GAIN WEIGHT AS WE AGE

Lots of us struggle to keep excess weight off as we age. Now, researchers at Sweden's Karolinska Institutet have uncovered why: the rate at which fat is stored and removed in fat cells slows as we get older. The team studied the fat cells of 54 men and women over a period of 13 years. They found that those who failed to reduce their calorie intake gained an average of 20 per cent of their bodyweight.



### HUMANS

# Meet your ancient relatives

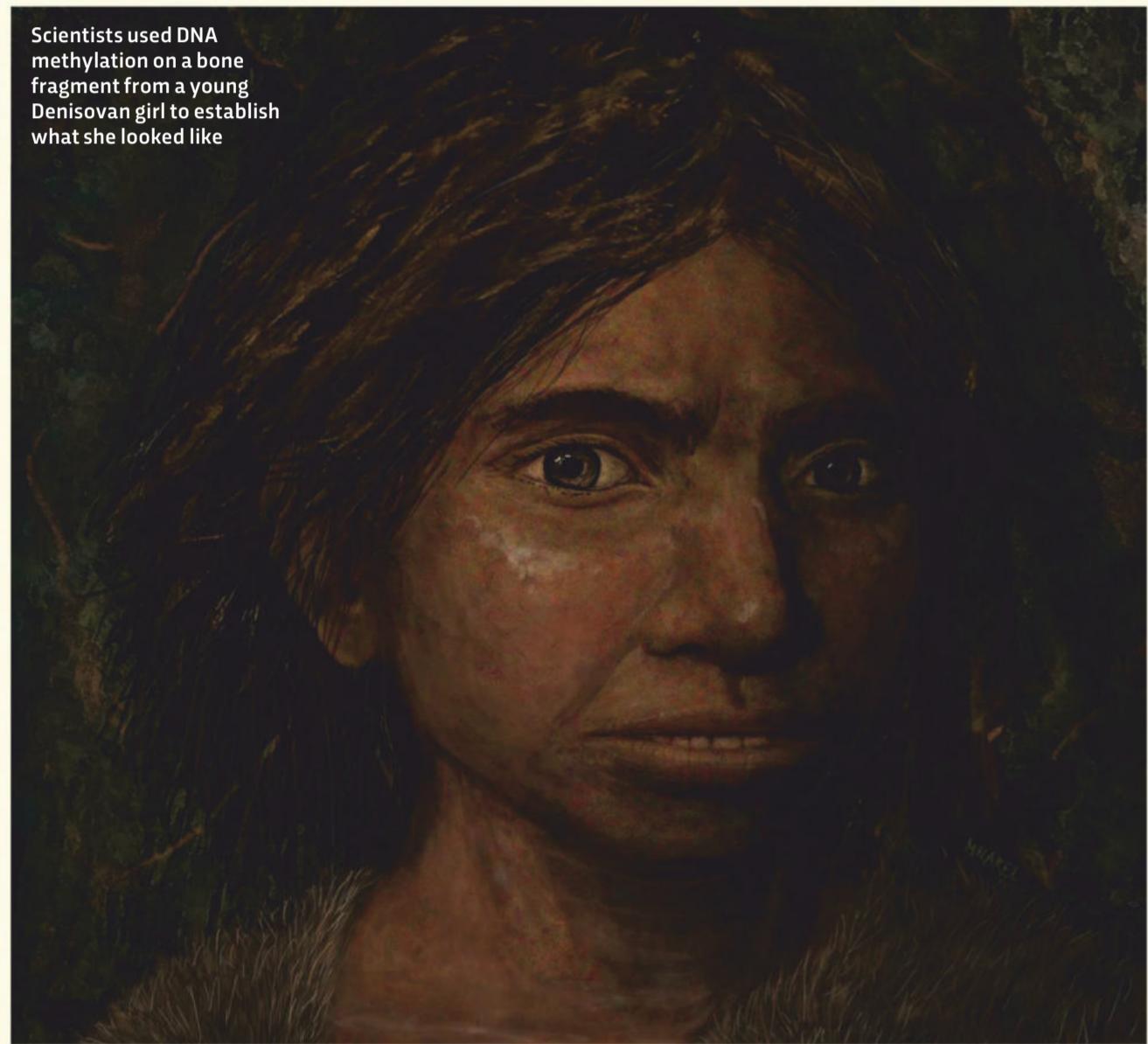
New research from the Hebrew University of Jerusalem has allowed us to look into the eyes of the ancient humans known as Denisovans for the first time.

Thousands of years ago, we lived alongside many human species, including Neanderthals and Denisovans. While scientists have managed to gather enough data from skeletal remains to paint a pretty good picture of Neanderthals, they have been unable to establish what Denisovans looked like, as their remains – part of a finger bone, a jaw bone and a few teeth – are so sparse.

While DNA was successfully extracted from the finger bone and informed scientists that the Denisovans were genetically distinct from Neanderthals and modern humans, it did not contain enough detail to provide them with much information about their anatomy. But by obtaining data through 'DNA methylation' – essentially the introduction of hydrocarbons to a DNA sequence – the scientists from the Hebrew University of Jerusalem have successfully reconstructed an image of the Denisovans.

DNA methylation affects genetic activity without altering the sequence. By comparing DNA methylation between Denisovans, Neanderthals and modern humans, the researchers found areas in the DNA that differed between the species. They then looked for evidence about what the Denisovans looked like, based on what happens in humans when those same genes lose their function.

Scientists used DNA methylation on a bone fragment from a young Denisovan girl to establish what she looked like



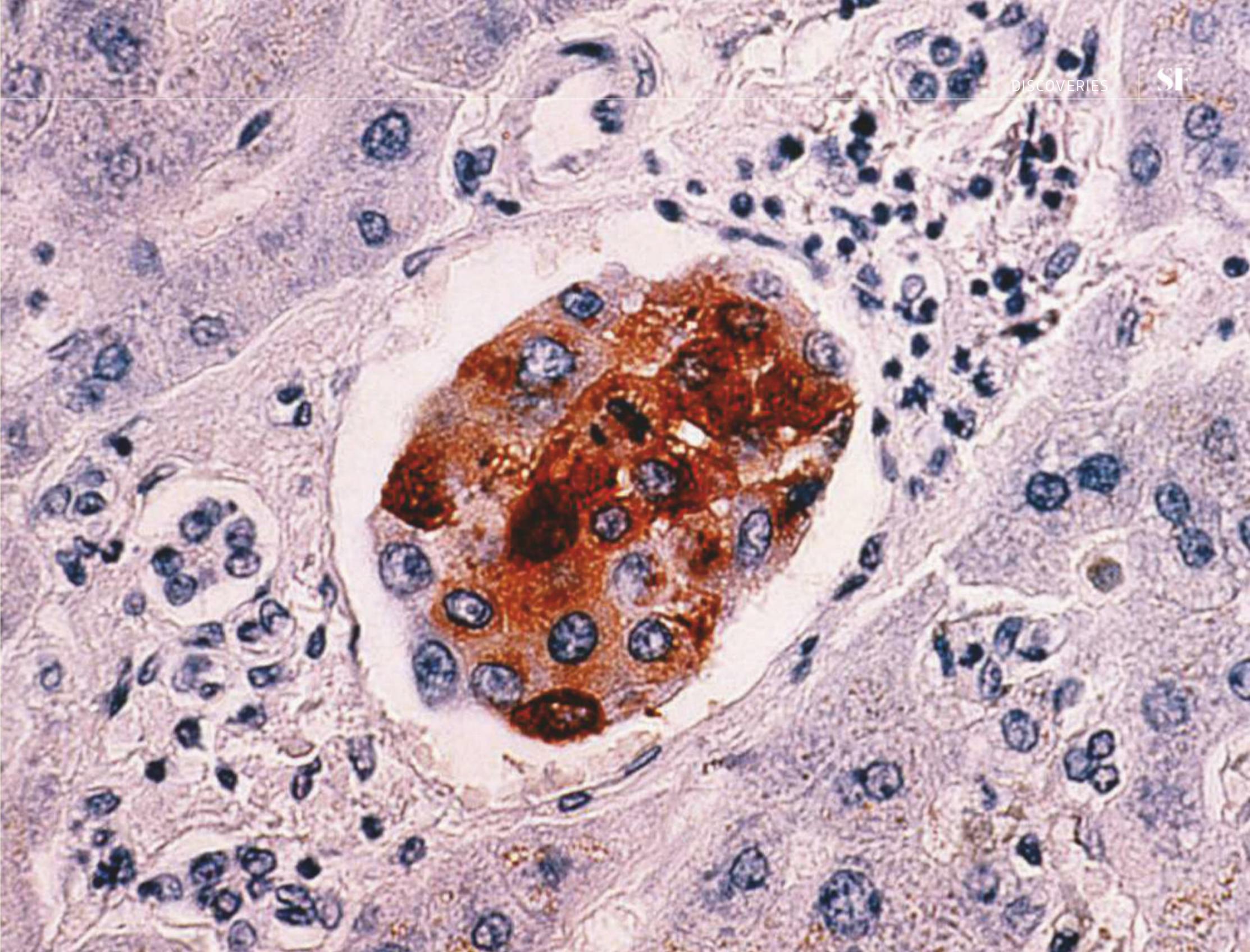
## “Denisovan anatomy can teach us about human adaptation”

“By doing so, we can get a prediction as to what skeletal parts are affected by differential regulation of each gene, and in what direction that skeletal part would change – for example, a longer or shorter femur,” said Dr David Gokhman, who co-authored the research.

In total, the researchers discovered 56 features – 34 of them in the skull – in

which Denisovans were different from Neanderthals and/or humans. They found that the Denisovans probably shared some Neanderthal traits, like a longer face and wider pelvis, yet also had unique differences, such as a larger dental arch and expanded skull.

“Studying Denisovan anatomy can teach us about human adaptation, evolutionary constraints, development, gene-environment interactions, and disease dynamics,” said Dr Liran Carmel, who co-authored the research. “At a more general level, this work is a step towards being able to infer an individual’s anatomy based on their DNA.”

**MEDICINE**

## Certain cancers are cannibals

**Some types of cancer cells will eat their neighbours to get nutrients and energy**

Cancerous cells will consume nearby tumour cells in order to regrow after chemotherapy, according to scientists at the Tulane University School of Medicine in New Orleans.

Chemotherapy drugs target the DNA of a cancer cell, the destruction of which, in most cases, causes the cell to die. But certain breast cancer cells are only stunned by chemotherapy, lying dormant instead of dead, in a state referred to as 'senescence'. These senescent cancer cells can then give rise to relapse tumours, and as such the survival rates of these cancers are low.

Dr James G. Jackson, who took part in the study, had previously identified that breast cancers with a gene called TP53 responded to chemotherapy with senescence. The team wanted to better understand how the senescent cells were able to regrow even after entering their dormant state.

In the laboratory, researchers saw whole tumour cells being engulfed by the senescent cancer cells. Once 'eaten', the cell would be digested, providing the cancer with the nutrients and energy it needed to regrow into a tumour. These cannibalistic cells survived longer than those that did not consume their neighbouring cells.

The scientists discovered that cannibalism was found in cells kept in cultures, as well as in tumours grown in mice. They also found that lung and bone cancers were capable of engulfing nearby cells as well.

"Inhibiting this process may provide new therapeutic opportunities, because we know that it is the breast cancer patients with tumours that undergo TP53-mediated senescence in response to chemotherapy that have poor response and poor survival rates," said Jackson.



## ENVIRONMENT

# Environmental Photographer of the Year 2019

This annual competition, sponsored by the Chartered Institution of Water and Environmental Management, celebrates the pictures that highlight the damage that humans are doing to our environment. Here are five of this year's winners...



2

## 1. Invisible

*Valerie Leonard*

At the Sisdol landfill site in Nepal, wastepickers rummage through garbage all day long, looking for materials or valuables to sell. This 'temporary' landfill, located near the country's capital Kathmandu, has been in operation since 2005, and is running out of capacity.

## 2. Remains Of The Forest

*J Henry Fair*

Hambach Forest in Germany was nearly 12,000 years old when it was bought by a power company to dig for coal underneath. The forest was once the size of Manhattan, but today just 10 per cent of it remains. Protests against this deforestation have been ongoing in the area since 2012.

## 3. Desperate Measures

*Neville Ngomane*

This looks like animal cruelty, but in fact the rhino is being dehorned

in a last-ditch attempt to save it from being killed by poachers.

## 4. Sewing Net

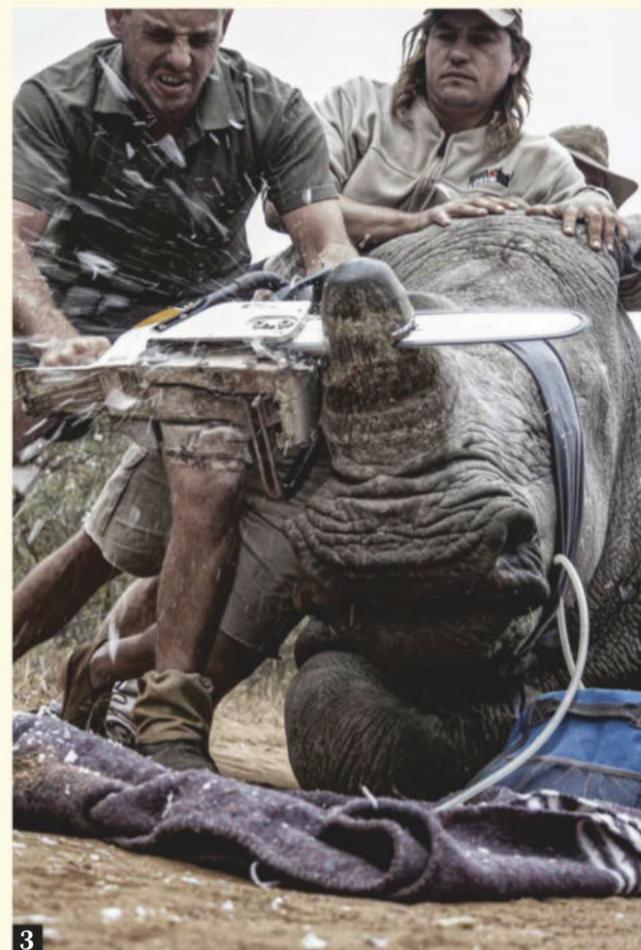
*Tran Tuan Viet*

As fish stocks decrease worldwide, fishermen have been turning to more extreme methods – such as the small-hole nets seen being manufactured here. This type of net can wreak havoc on marine biodiversity, as they trap ever-smaller species.

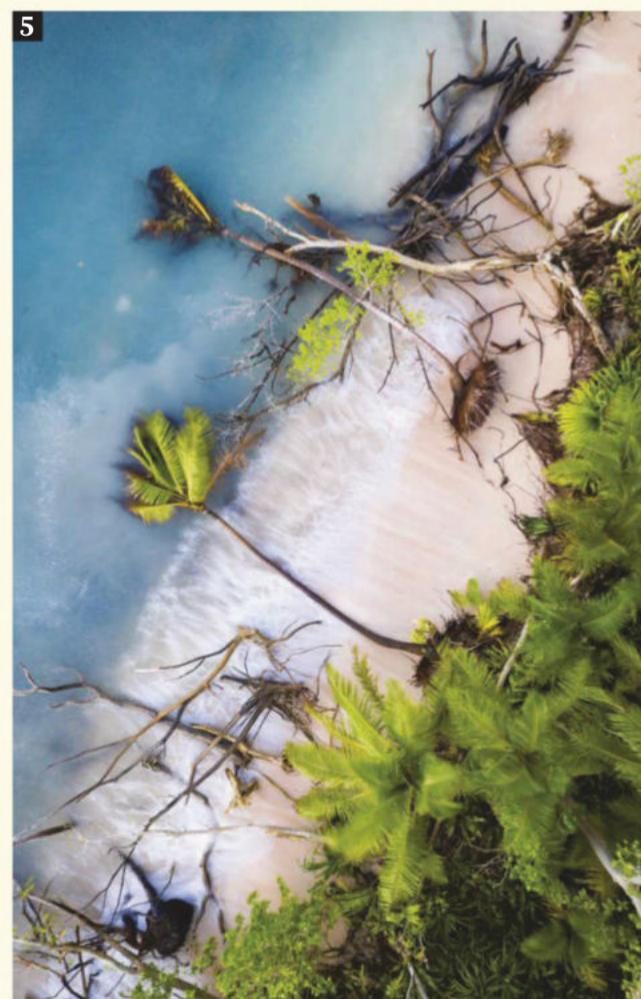
## 5. Beneath The Rising Tide

*Sean Gallagher*

Fallen trees lie on the sandy shores of Tuvalu's Funafuti lagoon as the waves lap around them. Land erosion has always been an issue for the tiny South Pacific nation, but its problems are intensifying as sea levels rise. Many, if not all, of the islands in the archipelago could soon disappear completely, putting the country's entire population at risk of being displaced.



3



5



4

Scientists use the Santa Ines glacier in Chile as an open-air laboratory to study climate change



## **SPECIAL REPORT**

# **IPCC warns of ocean emergency**

**The oceans affect the health of the entire planet. And according to the UN, if we don't reduce our emissions, much of the world will be looking at a future of flooding, drought and hunger**

In late September, in the same week that millions of people around the world joined the biggest climate protest ever, the United Nations (UN) released a shocking report on the impacts of the changing climate on the salty and frozen parts of the planet – the ocean and cryosphere. The ocean is warming, becoming more acidic and losing its life-giving oxygen; ocean-borne hurricanes are becoming more frequent and fearsome; rainfall patterns are shifting; frozen tundra is melting; glaciers and ice sheets are disappearing, contributing to sea level rise. That much was already clear, but the new report, assembled by the UN's Intergovernmental Panel on Climate Change (IPCC), reveals in stark detail the overwhelming scale and quickening pace of changes.

The report was three years in the making, and was prepared by 104 leading scientists from 36 countries and featured 7,000 of the latest studies. It is the most thorough climate-related health check for the ocean, poles and mountains – all of them linked by the common thread of water – and the prognosis is bleak.

Since 1970, the global ocean has been getting warmer, but from 1993 the rate of warming has more than doubled. In the

last decade, melting of ice in Antarctica has tripled compared with the previous decade, with similar losses of the Greenland ice sheet. Consequently, sea level rise is speeding up. All of this, and much more besides, is impacting species and ecosystems, from starving polar bears to bleached coral reefs.

### **HUMANS AT RISK**

As well as assessing the ecological damage, the report also takes stock of the soaring human costs. At greatest risk are the 680 million people living along low-lying coasts, another 670 million in mountain regions, plus five million in the Arctic and 65 million on small islands. Those are the people and communities who will most quickly lose their homes, food, drinking water, and livelihoods.

For anyone who doesn't live at altitude or near the sea, there's no room for complacency. As the report spells out, the



**“For anyone who doesn't live at altitude or near the sea, there's no room for complacency”**

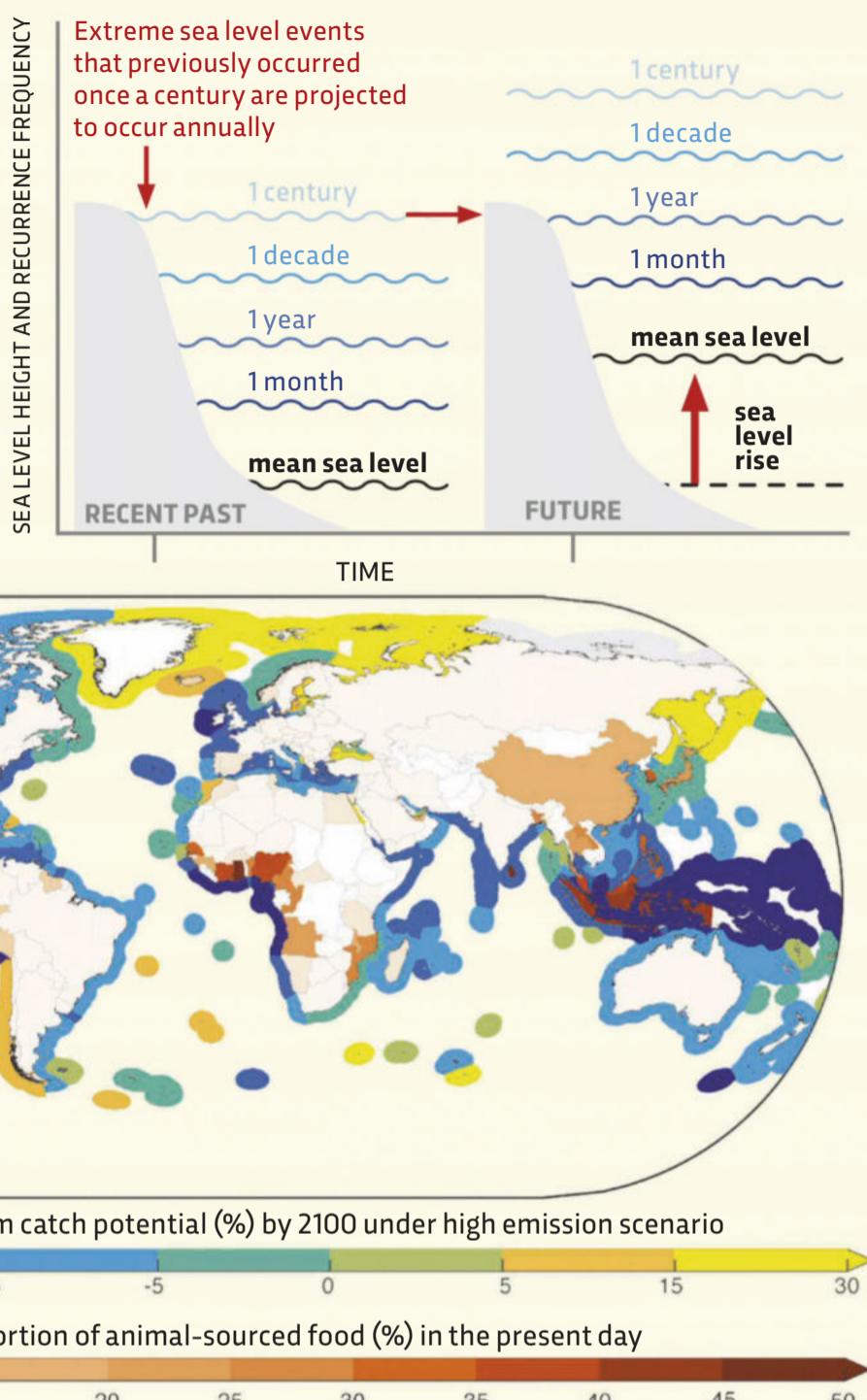
ocean and cryosphere play a critical role for life on Earth. The permanent melting of glaciers will reduce water supplies far and wide, and hydropower plants will be unable to generate electricity.

In many regions, there will be growing problems of food security as changes in rainfall affects what crops can grow. The fish we eat will change too; some species and populations of marine species will move and change their range to adapt



### TROUBLED WATERS

Even if we manage to reduce our emissions, there will still be far-reaching consequences across the planet. Sea level rises will become more frequent, and distribution of marine animals will change, affecting livelihoods and diets.



to rising temperatures, but others won't survive in a warmer, more acidic ocean. As a whole, the ocean will become less productive and less able to feed people around the world, especially in countries that rely the most on fish as a source of nutrition. Eating seafood will also become more dangerous, with increasing harmful blooms of algae contaminating the food chain, and the proliferation of pathogens.

The report casts a careful eye to the future and presents a range of forecasts of how things will likely turn out, depending on how effectively greenhouse gas emissions are cut. Some changes appear to be locked in and will go ahead no matter what. In many coastal areas, extreme floods that used to hit once a century will become a yearly occurrence by 2050, thanks to the triple whammy of rising, stormier seas. And whether or not carbon emissions are curbed, extreme El Niño and La Niña events will become twice

as likely this century compared to last, periodically altering rainfall, making some parts of the world wetter and others drier.

### TWO FUTURES...

Many aspects of the climate crisis play out differently under best- and worst-case scenarios. The IPCC report mainly focuses on two projections. One is a low emission future that limits global warming to 2°C by 2100. In contrast, the high emission scenario involves 'business as usual' with no effective policies to combat climate change. Comparing the two offers a sharp look at how much worse the climate crisis will be without immediate action.

Marine heatwaves, when sea temperatures soar by several degrees for prolonged periods, are already wiping out coastal ecosystems like mangrove forests and coral reefs. Under a low emission scenario, heatwaves are projected to become 20 times more frequent by the end

of the century; under the high emission scenario, they will be 50 times more likely. Just how much sea levels will rise also depends on how much emissions are cut. In the centuries to come, under the high emission scenario, there will be multi-metre rises by 2300. Keep emissions in check and sea level rise could be limited to only one metre.

Under the low emission scenario the ocean will hold onto more oxygen, acidification will be less severe and there will be more fish to eat. Crucially, this option will also slow down the speed of inevitable change, giving people and ecosystems more time to adapt. The hopeful message in the IPCC report is that there is a chance to avoid the worst and there are still choices to make about the future of our living planet.

by DR HELEN SCALES (@helenscales)  
Helen is a marine biologist, writer and broadcaster.

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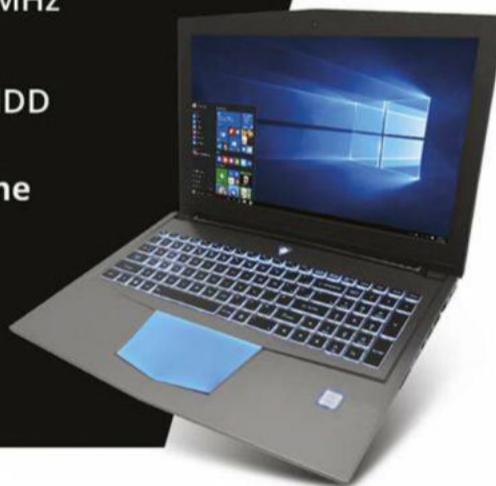
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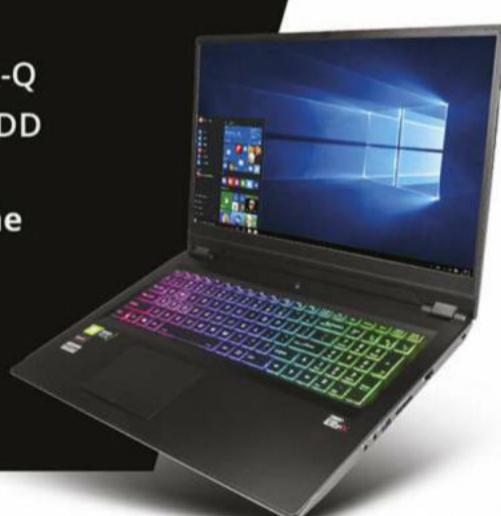
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# REALITY CHECK

SCIENCE BEHIND THE HEADLINES

Stranded cetaceans | Peaceful protest | Antibiotic resistance



ANALYSIS

## WHALES AND DOLPHINS: WHY ARE MORE OF THEM BEACHING AROUND THE UK?

A report has found that cetacean strandings around the UK have increased by 15 per cent. What's causing it?

X

## “Chronic noise from shipping and off-shore wind farms can drive animals away from their usual habitats and into dangerous environments”



Visit the BBC's Reality Check website at [bit.ly/reality\\_check](https://bit.ly/reality_check) or follow them on Twitter @BBCRealityCheck

### WHY DO WHALES AND DOLPHINS BECOME STRANDED?

Nearly 5,000 whales, dolphins and harbour porpoises were stranded on shores around the UK in the years 2011-2017, according to a report published in September by the UK Cetacean Strandings Investigation Programme (CSIP). As many cetaceans spend a lot of time at depth it's hard to measure populations accurately, so we can't say for sure whether this number of strandings is a threat, but for some pods, such as the eight-strong West Coast Community of orcas near Scotland, the loss of even one or two individuals is bad news.

Though 132 of the animals were refloated, many died as a result of human activity, says lead researcher Rob Deaville. “Bycatch and entanglement are the main direct man-made drivers of mortality,” he explains. Whales and dolphins can get caught up in fishing lines and nets, which causes easily identifiable injuries. Ship-strike is another common cause of death that's readily detectable.

Whales and dolphins can also ‘beach’ as a result of illness, often caused by parasites, starvation or human pollution. “Chemical pollution can cause issues, because some of these contaminants can affect the immune system,” Deaville explains. Polychlorinated biphenyls (PCBs), for example, were widely used as industrial coolants until they were banned in the 1970s for being carcinogenic. PCBs stick to fatty tissue, so they linger in the food chain, and levels in the ocean remain high. Several whales were also found with plastic or marine litter in their stomachs, though only one died as a direct result.

Cetaceans are split into two subgroups: baleen whales, which include the blue and humpback whales, and toothed whales, which include dolphins, orcas, porpoises and sperm whales. “All the toothed cetaceans use echolocation as their primary sense. They are primarily acoustic animals and they live in an acoustic environment,” Deaville says. As a result, they are highly susceptible to noise pollution. Chronic noise from shipping and off-shore wind farms can drive animals away from their usual habitats and into dangerous environments, while sudden, acute noise from explosions, seismic activity or sonar can



temporarily deafen them or even cause haemorrhaging in the inner ear. Naval sonar is particularly damaging. “There are many accounts globally of mass strandings associated with some particular forms of sonar,” says Deaville.

### WHY DO MASS STRANDINGS OCCUR?

Whales and dolphins are social animals. Many cetologists believe that whales will accompany their ill or injured friends and accidentally end up stranded with them. As a result, mass strandings often contain several otherwise healthy animals.

### WHERE DO STRANDINGS HAPPEN MOST?

A New Zealand-based study found that herds of whales are most often stranded in areas with the same geography: a long sandy beach with a gentle slope, with a peninsula or cape at one end. “Whales do not strand at random locations,” write the authors. It’s not clear why this is, although marine biologist W H Dudok van Heel proposed that gentle slopes disrupt the cetaceans’ echolocation systems. However, ➤

**LEFT**  
Rescuers attempt to save a sperm whale that has beached in the Wash on the eastern coast of the UK

**ABOVE** An orca pod off the coast of the Shetland Islands.

► more recent studies have shown that the sand kicked up on shallow beaches doesn't affect how well sound is transmitted.

The North Sea acts as a trap for northern bottlenose whales and Sowerby's beaked whales. These species migrate southwest from the North Atlantic every year, normally keeping the British Isles to their east. If any of them travel via the North Sea instead, perhaps because they were chasing prey or got lost, they often end up stranded on east coast estuaries such as the Firth of Forth or the Thames estuary.

#### WHY HAVE STRANDINGS INCREASED IN THE UK?

It's hard to tell. It's possible that bycatch and pollution have increased pressure on many species, but this is not necessarily the case.

"Yes, there was an increase in strandings, but sometimes an increase in strandings can just mean that there are more of a species out there," Deaville explains. "In fact, from the point of view of conservation scientists, we're much more concerned about species that *don't* strand where we might expect them to."

In fact, the true number of strandings may not be increasing at all. In Scotland, there has been a drive to encourage members of the public to report stranded cetaceans they find. It could be that numbers in Scotland are steady, but reporting is more thorough.

#### WHAT DO I DO IF I FIND A STRANDED CETACEAN?

If the animal is still alive, phone the RSPCA/SSPCA. Keep it wet and cool by gently pouring water over it – avoiding the blowhole – if you think it's too hot, but otherwise keep your distance to avoid making the animal even more stressed. Especially stay away from the tail.

When trained handlers arrive, they may try to refloat a smaller animal. However, cetaceans are used to having water to support their bodies, so beaching can cause severe internal injuries. The animal may re-strand or die a few days after refloating.

If, unfortunately, it has already died, then phone CSIP's freephone hotline: 0800 6520333.

—  
by SARA RIGBY

*Sara is online assistant at BBC Science Focus. She has an MPhys in mathematical physics.*

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#### REVIEW

## PEACEFUL PROTESTS: ARE NONVIOLENT DEMONSTRATIONS AN EFFECTIVE WAY TO ACHIEVE CHANGE?

Mass protests arranged by climate campaign group Extinction Rebellion brought busy streets to a standstill again this month. But are non-violent campaigns like this the best way to raise public awareness of a cause?

In August 2018, 15-year-old Greta Thunberg sat in front of the Swedish parliament building to protest for greater action on the climate crisis. She wanted the government to pledge to reduce carbon emissions. A month later, on the



**LEFT** First set up in the UK in 2018, Extinction Rebellion is now a worldwide phenomenon

**BETWEEN** Schoolchildren all over the world have been striking to demand decisive action on climate change



day before the Swedish general election, Greta announced that she would continue to strike every Friday until the country's policy changed. Her slogan was FridaysForFuture, which went on to represent the global school's strike for climate. Now, just a year later, students and adults around the world have joined FridaysForFuture strikes.

Many other people have joined the UK-based group Extinction Rebellion, or XR. This group came into being around the same time as Greta's first strikes, and is made up of nonviolent protesters worried about the threat of mass extinction by climate change. The group's first act of civil disobedience was in October 2018, when a crowd of 1,500 gathered in Parliament Square. Over the course of the following weeks, they blocked bridges and glued themselves to the gates of Buckingham Palace. Through this disruption, they hoped to bring attention to the climate emergency.

In the 12 months since that first protest, the movement has grown to see 150,000 people on the XR mailing list. There are 156 different countries with at least one XR member.

Roger Hallam, one of the founders of Extinction Rebellion, says he was inspired by the 2011 book



**“Civil resistance is the backbone of the XR movement – any action attributed to the organisation must be nonviolent”**

*Why Civil Resistance Works.* The book's co-authors, political scientists Erica Chenoweth and Maria J Stephan, analysed data on over 300 violent and nonviolent major political campaigns in the last decade. They found that nonviolent campaigns had been twice as effective as the violent campaigns: they succeeded about 53 per cent of time, compared to 25 per cent for an armed resistance.

As a result, civil resistance is the backbone of the XR movement – any action attributed to the organisation must be nonviolent, and being arrested is not a requirement of getting involved. Stephan is now a director of the Program on Nonviolent Action at the US Institute of Peace. She notes that a ➤



● campaign cannot just be a one-off. It has to be a sustained sequence of actions – and not just street protests – to succeed. “Some of the most powerful tactics in nonviolent resistance can be refusing to buy products, or ‘stay at homes’ – non-cooperation with the status quo,” she says.

Stephan stresses that “we don’t claim that nonviolent resistance always works”, but in terms of both immediate and longer-term impacts, nonviolent resistance does seem to produce more positive and beneficial results. Stephan uses the example of Tunisia, where peaceful street protests during 2011’s ‘Jasmine Revolution’ led to the ousting of President Zine El Abidine Ben Ali and the formation of a stable democracy, whereas other more violent Arab Spring protests have typically resulted only in ongoing conflict.

Stephan’s co-author Erica Chenoweth took their research further, and found that no regime or incumbent leader had remained in power when at least 3.5 per cent of the population had participated in active protest against it/them. That’s not to say, however, that success is guaranteed simply because

X

**“Teenagers are almost wired to be contrary, to be a bit rebellious. They are able to recruit and persuade more reluctant older folks”**

a movement attracts the participation of a magical 3.5 per cent of a population.

#### SO HOW DOES A CAMPAIGN ATTRACT PEOPLE AND THEN KEEP THEM ENGAGED?

Psychologist David Halpern, director of government partner The Behavioural Insights Team (nicknamed ‘the nudge unit’), likens the dissemination of an idea to the adoption of new technology. Consider the spread of mobile phones: once the preserve of an elite few, today they’re part of everyone’s daily lives. The uptake of ideas follows a similar pattern.



**ABOVE LEFT** 16-year-old Greta Thunberg has become a figurehead for the environmental movement, and has the ear of many world leaders

**ABOVE** Extinction Rebellion only encourages nonviolent protests

This pattern was suggested by Everett M Rogers in his book *Diffusion Of Innovations*. First, there are innovators, the ones who champion something from day one. These then influence 'early adopters', people who are "considered by many to be the individual to check with before adopting a new idea," writes Rogers. These in turn influence the majority, then finally "those who tend to be suspicious of innovations and of change agents."

Greta Thunberg is an example of an innovator, says Halpern. "She personifies a lot of this. She's persistent and authentic. One of the things that undermines a message is if you yourself are not consistent. Then people will just view you as hypocritical. She embodies it."

Key to the more widespread adoption of an idea, however, is the ability to keep on recruiting *past* the innovators and early adopters. "The protests that grow to scale are able to recruit people. And if you get that wrong, you won't get your early majority assembled," says Halpern.

In the climate movement, it's the younger generation who are the early adopters. "Teenagers

are almost wired to be contrary, to be a bit rebellious," notes Halpern. "They are able to recruit and persuade more reluctant older folks."

Elements of a protest can, however, *dissuade* people on the fence from joining a movement. "We're built to absorb information which supports our prior beliefs," explains Halpern. So if you were sceptical about climate change and were then met with angry protestors blocking your route to work, you'll 'asymmetrically absorb' this information and it'll give you an excuse not to adopt.

But not everyone has to be completely onboard: the early adopters just need to influence the majority enough. "Most people might not be thinking 'I'm prepared to go to extraordinary lengths to change my lifestyle', but they create a critical mass such that you get adoption of electric vehicles, smart meters, etc," says Halpern.

### WITH PARTICIPATION IN CLIMATE PROTESTS GROWING, WHAT CAN WE EXPECT TO SEE NEXT?

In Stephan and Chenoweth's research for *Why Civil Resistance Works*, they found that the average duration of a nonviolent campaign was three years.

"Three years was for maximalist campaigns with major political goals, which is not to say the climate movement will take any shorter or longer, but there are different variables and different mechanisms of change," explains Stephan. "It's hard to put a timeline on it. But scientists demonstrate that time is running out [for climate action]." They also found that the average duration for violent campaigns was three times that of nonviolent. "Often, people will say, 'Nonviolence isn't working, we need to take up arms to win more quickly!'. But there's not a lot of evidence that that is the case."

Stephan has friends and colleagues who are involved with the protests, and says she will probably show up herself for some of the Washington, DC portion of the strikes.

"The youth face [of the movement] is really powerful," she says. "It's got lots of new and different people involved and actively engaged in the most pressing issue of my generation."

by AMY BARRETT

Amy is editorial assistant at BBC Science Focus.

## COMMENT

# ANTIBIOTIC RESISTANCE: IS IT REALLY AS DANGEROUS AS CLIMATE CHANGE?

Earlier this year, the UK's chief medical officer said antibiotics could kill us before climate change. These drugs were once seen as 'miracle cures' – so is the threat really that bad?

**E**very now and then we hear of another new antibiotic-resistant bacterium. In fact, according to a recent report by Public Health England, 19 new strains have developed mechanisms to resist antibiotics over the last decade. A good example is the 'last resort' colistin, which was the last effective antibiotic held in reserve – until 2015, when researchers reported the emergence of colistin resistance in *E. coli*.

Today, it is hard to imagine modern medicine without antibiotics, the 'magic bullets' that enable us to perform the most incredible life-saving interventions, including organ transplants and heart surgeries. However, since the discovery of penicillin, bacteria have been able to 'strategically' find ways to resist the effects of antibiotics, so that they are not killed, or their growth is not stopped.

It's not just human medicine that has this influence. Antimicrobial resistance, or AMR, naturally occurs in the environment, as many species of bacteria produce antimicrobial agents of their own. To survive such environmental exposure, bacteria have to find ways to avoid the effect of such antimicrobials. One of the most common ways is by transferring the genes that provide resistance between species. In other words, the natural environment already contributes to the selection of antibiotic-resistant microorganisms, even without human intervention.

X

**"Widespread use of antibiotics in farm animals contributes to the development of resistant bacteria that can be transmitted to humans"**

## A CRISIS IS ALREADY UNDERWAY

AMR is not a problem that will happen in the future: it is happening now.

Currently, 700,000 people die worldwide every year from infections that no longer respond to antibiotics. It is estimated that the number of deaths will increase to 10 million per year by 2050, consequently costing healthcare systems 100 trillion US dollars (£90 trillion), unless measures are implemented to control the spread of AMR. In addition to the human death toll, AMR reduces the effectiveness of standard treatment, which results in prolonged patient illness and longer stay in hospitals, thus increasing healthcare costs. Recently, the World Health Organisation has warned that we are entering the "post-antibiotic era," when there could be very little done to treat simple infectious diseases.

AMR is a complex phenomenon largely impacted by human activities, behaviour and socioeconomic and environmental factors. High production and usage of antibiotics (hundreds of thousands of tonnes per year), the release of pharmaceutical manufacturing waste into the environment, uncontrolled use of 'antibiotic growth promoters' in animals, and the ability to buy antibiotics over the counter have led to serious antibiotic resistance issues.

The misuse and overuse of antibiotics creates a favourable environment for promoting resistance among susceptible bacteria. For example, widespread use of antibiotics in farm animals contributes to the development of resistant bacteria that can be transmitted to humans through food consumption. This in turn can lead to foodborne infections that become increasingly difficult to treat.



Recently, my research showed that bacteria resistant to multiple antibiotics are widespread in non-healthcare environments. The fact that the AMR levels in public settings were comparable with those found inside the hospital suggests that such public places may well be reservoirs for antibiotic-resistant bacteria capable of moving between hospitals and humans.

#### AMR AND CLIMATE CHANGE

AMR is a global issue. It is as serious a threat as climate change, and just like climate change, neutralising the threat will require concrete global efforts.

In fact, a 2018 study published in *Nature Climate Change* found that global warming may be accelerating the problem of AMR.

Bacteria thrive at higher temperatures that provide them with a favourable environment to rapidly increase in numbers, creating better opportunities for mutations and transmission.

The good news is that with collective efforts we can tackle AMR. Everyone in the world can contribute to solving the problem: by simply limiting their use of antibiotics to only when they are needed, and by promoting AMR awareness campaigns, for example, on social media. Without human-induced antibiotic exposure, bacteria may well return to their 'susceptible' state.

The world is running out of effective antibiotics, and we simply aren't discovering enough new ones – no new classes of antibiotics have been discovered for decades. Our children and grandchildren will inherit the world as we leave it to them – we need to make the right choices to make our planet a better place for them. **SF**

**Indiscriminate use of antibiotics like these can lead to the spread of antimicrobial resistance**

by **HERMINE MKRTCHYAN**

*Dr Hermine Mkrtchyan is a Senior Lecturer in Biomedical Sciences at the University of East London, specialising in antimicrobial resistance and its transmission between species.*

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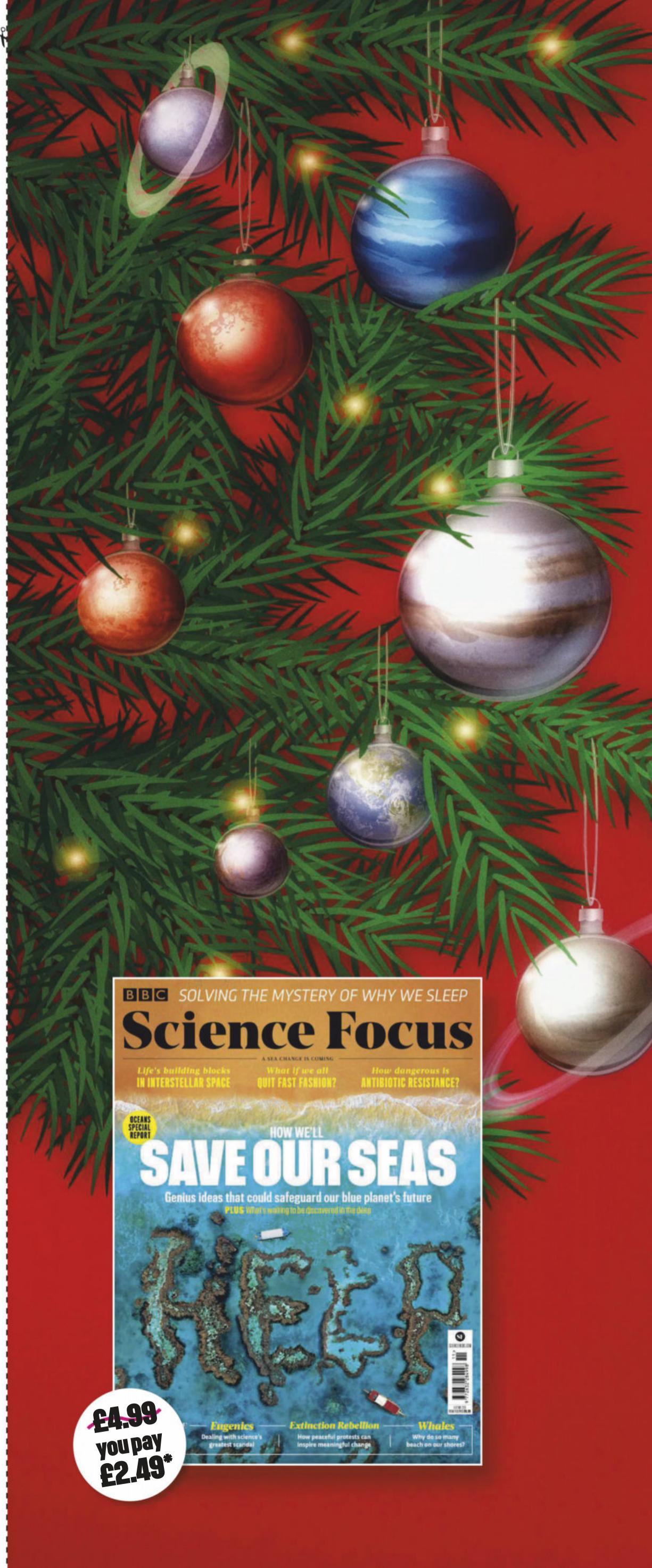
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These fighter pilot swimming goggles can be our wingman any time p46

# INNOVATIONS

PREPARE  
YOURSELF  
FOR  
TOMORROW



## SPEAKER LOVE

According to market research from voicebot.ai, 1 in 4 US adults now owns a smart speaker



## 90 minutes

The amount of time that Spot the robot dog can run for between charges or you can swap out the battery for a fresh one.



**Ring Stick Up**

This new security cam from Amazon-owned Ring sticks to any surface and beams footage to Alexa-enabled devices.

£89

**Echo Studio**

This clearer, louder version of the original Amazon Echo is ideal for those who mostly use the speaker for music and podcasts.

£189.99

**Echo Flex**

If you *really* love Alexa, then this plug with mic and speaker lets you install it anywhere with Wi-Fi and power.

£24.99

**FIRST LOOK**

# Alexa, Don't Leave Me

**Coming to a face near you: Amazon launches new smart glasses that will help you control your smart home hands-free**

Amazon's digital voice assistant Alexa can now leave the house and follow you wherever you go, via three new wearable gadgets: a ring, earbuds and glasses.

The new glasses, called Echo Frames, connect to an Android phone (there's no iOS support yet) and let you speak to Alexa and hear its responses via a microphone and some microdirectional speakers embedded in the frame that you, and only you, can hear. The frames can also be used to listen to music or podcasts and make calls. The idea being that you might want to turn on the heating at home or listen to an email, without having to go to the effort of using your fleshy hands. The new Amazon EchoBuds (£119.99) work in largely the same way without the need for glasses.

Just like the Amazon Echo home speaker, the Alexa aboard the Echo Frames is always listening, but not recording. Once you summon Alexa, your utterances are logged and the audio is sent to the Amazon servers where it's processed and stored.

Amazon say the audio may be listened to in order to improve how Alexa understands our natural speech.

Unlike Google's foray into the world of smart glasses (Google Glass, RIP), there's no heads-up display embedded into the lenses here, although Amazon says you will be able to fit the frames with prescription lenses.

The new Amazon Echo Loop ring works a little differently. It houses an action button that you use to wake Alexa and click twice to talk to it. There's even a teeny, tiny speaker that will whisper its replies back to you. There's also a haptic engine inside that will vibrate when your

smartphone (this one does work with an iPhone) gets a notification. The Loop works with Google Assistant and Apple's voice assistant Siri, too.

Amazon is aware that some people feel uncomfortable inviting Alexa into their home, let alone to sit on their face. So at the product launch the company detailed new tools that let you manage your privacy. There is an improved Alexa portal that gives you more control over how long your data is stored, and you can choose to stop Amazon collecting your recordings altogether.

At the moment both the Echo Frames and Echo Loop are invite only – you just have to apply via its website. If, like us, you're a little cynical about home assistants and you're not quite ready live out the movie *Her*, then you're in the minority. Amazon reported it has already sold 100 million devices with Alexa on board. Who knows what's next?

→  
The wireless EchoBuds let you listen to music, audiobooks and podcasts, and make calls with the bonus of Alexa connectivity



**"IF YOU'RE A LITTLE CYNICAL ABOUT HOME ASSISTANTS, THEN YOU'RE IN THE MINORITY"**

## THE ESSENTIALS

# Northern lights

As the clocks go back in the UK, trips to the Arctic to see the aurora borealis become viable. Here's our pick of the five things you shouldn't be without...



## 1. Men's Stretch Storm Nano Jacket

Any trip to the Arctic demands layers, and lots of them. Wear them when you're cold and take them off if you start to sweat. But you need a reliable coat to top it off. Our pick would be this coat from Patagonia, built to handle sleet, hail and snow. Made for climbers, its insulation feels like a duvet, while the outer layer is light and stretchy, so you can move freely. It initially caught our attention for using nylon made from recycled fishing nets.

£350, [patagonia.com](http://patagonia.com)

## 2. Nikon D850

You'll want a camera with manual settings, so you can set your own ISO, aperture and shutter speed. But if you want to go all out, professional aurora hunters recommend this camera or the more affordable Nikon D810. Its sensor crisply picks up the ephemeral wisps of the aurora, without embedding much noise in the image. And the layout is so simple that you can use it even with frozen thumbs in the dark. Pair with one of Nikon's brilliant ultra-wide angle lenses.

£2,699, [nikon.co.uk](http://nikon.co.uk)

## 3. Mophie Powerstation 3XL

With the incredible views on offer in the Arctic, your batteries – both in your camera and smartphone – will take a drubbing. Batteries also drain faster in colder climes, so it's wise to take a back-up. The Powerstation will charge a smartphone for an extra 83 hours of use (we managed to charge an iPhone X three times) and has ports to juice up multiple gadgets at once. We even ran a Macbook off it for a day.

£59.95, [zagg.com](http://zagg.com)

## 4. Garmin DriveSmart 65

If you're travelling under your own steam, you'll need a reliable sat-nav to navigate the northern wilderness. Norway, Sweden and Finland have brilliant roads, but it's useful to know where every petrol station and rest stop is on your route – especially if you're trying to get off the beaten track. The DriveSmart's responsive touchscreen, voice-controlled features and smartphone-esque controls set it apart.

From £149, [garmin.co.uk](http://garmin.co.uk)

## 5. GorillaPod 5K

A tripod is a must-have if you're going to get a good shot of the night sky. Long exposures mean that any movement or shaky hands will render a photo a blurry mess. We chose the GorillaPod 5k as it's light, small and versatile, while still sturdy enough to hold a heavy DSLR with lens attached. Its articulating limbs mean it'll stand on any surface, or wrap around a handrail. You don't have to unpack any extendable legs either, letting you set up shots quickly.

£82.95, [joby.com](http://joby.com)



## Second skin adds sense of touch to VR

A soft, wearable synthetic skin created by scientists at the Swiss Federal Institute of Technology Lausanne could simulate the sense of touch in virtual reality.

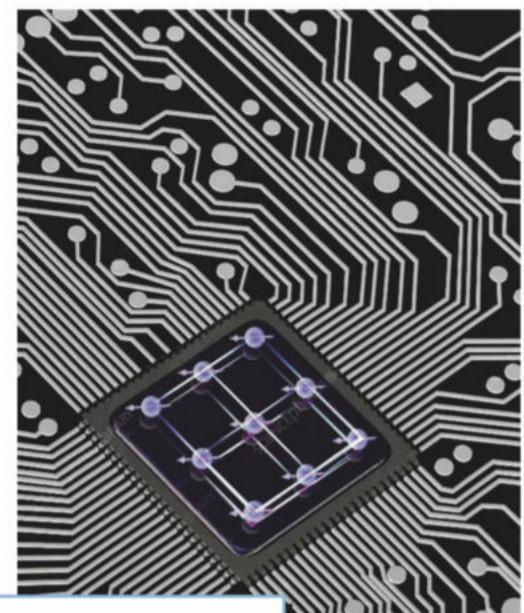
The second skin's creators, led by roboticist Harshal Sonar, hope to use the tech to better understand how our senses work and help rehabilitate patients who lose their sense of touch or proprioception – our innate awareness of where our body is in space. “The next step will be to develop a fully wearable prototype for applications in rehabilitation and virtual and augmented reality,” says Sonar.

The artificial skin is intended to cover the surface of your hand, for example, and simulate touch via a combination of pressure and vibration. In the first prototype pictured above, the silicon membrane has air pumped around its surfaces by specialised actuators that can

**“THE ARTIFICIAL SKIN IS INTENDED TO COVER THE SURFACE OF YOUR HAND, FOR EXAMPLE, AND SIMULATE TOUCH VIA PRESSURE AND VIBRATION”**

inflate and deflate 100 times a second, approximating the sensory input you get when you touch a surface.

The artificial skin is also loaded with sensors that monitor how the wearer's skin deforms in response to the stimulations, which will be different from person to person. This feedback will go directly into the system in real time to improve the naturalness of the sensation.



## TECH DIGEST

### QUANTUM SUPREMACY

**Google has achieved it, we think.** This is the point at which a quantum computer can perform a task that a conventional supercomputer couldn't. It seems that Google's quantum computer solved a calculation in 200 seconds that would take the world's most advanced supercomputer 10,000 years.

**But it's not confirmed yet.**

A research paper documenting the achievement was spotted by the *Financial Times* on a NASA website before being taken down, presumably to be submitted to a scientific journal for review.

**Quantum computers are strange.** A conventional ‘bit’ is either a 1 or a 0, which represents a piece of information. A quantum bit, or qubit, can be a combination of both 1 and 0 at the same time. Pair this idea with a bunch of other quantum phenomena and you have a computer that can crunch through large batches of data in parallel, rather than sequentially.

**This is could be huge.**

Quantum computers aren't likely to become home PCs, but when it comes to solving problems involving huge datasets, in drug discovery for example, it could lead to huge advances. If Google and NASA have really achieved ‘quantum supremacy’, there's still a way to go to broaden the work out to other calculations.

# Ideas we like...

1.

## Robot dogs

Boston Dynamics has been wowing the world with videos of its robots for the best part of a decade now. After all that training, their robot dog, Spot, is ready to leave the lab and is available to buy. This mechanical pooch can walk at nearly 5km/h, self-right and steady itself if bumped. Spot can also open doors, carry payloads of up to 14kg over tricky terrain and, we're told, is a good boy. Boston Dynamics anticipates it'll be used to inspect dangerous or remote sites to keep human lives safe.

[Spot, bostondynamics.com](http://Spot, bostondynamics.com)



2.

## Bins that take themselves out

Andrew Murray, creator of the Smartcan, made this self-driving bin prototype so that we might, one day, be free from this menial chore. The motorised, internet-connected bin drives itself between two docking stations. Whether you'd be allowed to leave a docking station in the street is another question, but it's nice to see smart home tech that tries to make life simpler rather than more complicated.

[Smartcan, £TBC, smartcan.app](http://Smartcan, £TBC, smartcan.app)

3.

## Fighter pilot swimming goggles

These goggles use an onboard computer to track your swim and they project the data back on to your lenses, just like a fighter pilot's heads-up display. Data from accelerometers and gyroscopes mixed together with a bit of AI keep track of metrics like your stroke rate, lap count, split times and more. You can choose which stats you want to track via the app before you dive in.

[Form Swim, \\$199 \(£161 approx\), formswim.com](http://Form Swim, $199 (£161 approx), formswim.com)



#### 4. Watches powered by your body heat

The difference in temperature between your skin and this watch charges its batteries, so you never have to plug it in. It can monitor your heart rate and has GPS too, so you can chart your fitness, whether you're walking, running, swimming or cycling. And just in case you're a bit too sedentary, the watch is solar-powered as well.

Powerwatch 2

\$499 (£408 approx), [powerwatch.com](http://powerwatch.com)

#### 5. Wireless charging lamps that don't break the bank

This diminutive, but multi-talented lamp is powered via USB, houses a Bluetooth speaker and offers three different LED modes. Plus, you can use it to charge up any wireless-compatible smartphone by simply popping the phone on the lamp's base. It's lightweight too, so perfect for shoving in your bag for trips away.

Groov-e Apollo, £29.99, [groov-e.co.uk](http://groov-e.co.uk)



#### 6.

#### Nanospun clothes

North Face's new material Futurelight (pictured left) will land in stores this month. The fabric is woven with its new "nanospinning" technology which, according to North Face, lets them regulate the size and concentration of pores in the fabric, to control how much air gets out without sacrificing on waterproofing. The range runs across climbing, skiing and hiking clothing, and is one of the biggest advances in fabric tech we've seen for a while.

North Face FutureLight,  
Various products available, [northface.co.uk](http://northface.co.uk)

#### 7.

#### Virtual hands

Oculus Quest, our favourite VR headset, will soon be able to track the movement of your hands, without needing controllers. The system currently relies on a pair of remotes to let you interact with the virtual world, but a software update in 2020 will let the camera at the top of the headset scan and track your hands and fingers so you can use them to manipulate objects in the VR world.



Oculus Quest, £4.99, [oculus.com](http://oculus.com)

#### 8.

#### Dual-screened tablets

Microsoft has unveiled a smartphone-tablet hybrid that folds like a book. The Surface Duo sports two displays, and each will be able to run different apps, so you can take notes while taking a call, for example. It's not on sale until next year, so specs haven't been released, but Microsoft said it will run Android rather than a Windows operating system.

Microsoft Surface Duo, [microsoft.com](http://microsoft.com)



# HOW WE CAN SAVE THE CORAL



Watch *Seven Worlds, One Planet*, coming soon to BBC One. Check *Radio Times* for details.

Seven-tenths of the world is covered by the oceans. They put food on our plates, regulate the climate, and provide up to 85 per cent of the oxygen we breathe. But human activity is putting that at risk. On 25 September, the Intergovernmental Panel on Climate Change presented a report on the oceans that made dire reading (p28). It said that even if greenhouse gas emissions declined sharply and global warming was limited to less than 2°C, sea levels could still rise by 30 to 60cm by 2100. Plus, we're emptying the oceans of animals,

having passed the point of 'peak fish' in 1992 when total global catch began a relentless decline. A third of marine mammals are at risk of extinction. Our carbon emissions have made the oceans 300 per cent more acidic since pre-industrial times, threatening aquatic life in many ways. But many people are working to turn things round. "There are lots of solutions out there," says conservation scientist Dr Heather Koldewey, from the Zoological Society of London. "It is quite extraordinary, the power of good in the world."

# THE OCEANS AND HOW THEY CAN SAVE US

by DR HELEN SCALES

# PART ONE

HERE ARE SOME OF THE  
BRIGHTEST AND BEST  
INITIATIVES THAT HOPE  
TO SAFEGUARD OUR  
OCEANS' FUTURE

## THE SMART MACHINE THAT CATCHES PLASTIC AT THE SOURCE

Plastic particles have become ubiquitous in our seas. They have been spotted in remote areas of the poles and in the deepest ocean trenches.

While a number of projects focus on removing plastics from the seas, tech start-up Ichthion is developing a system for extracting plastic waste from rivers. Rivers play a big part in the plastic problem in the oceans, because they sweep tonnes of waste from land out to sea. "What we're doing hundreds of thousands of miles inland really does have an impact," explains conservation scientist Dr Heather Koldewey, who recently took part in an expedition that tracked plastic waste along the River Ganges.

Ichthion's Azure device sits on a river's surface and diverts floating objects towards the river banks, where a conveyor belt lifts them up and runs them past a camera. An artificial intelligence algorithm then recognises the shapes and colours of different plastics and packaging brands. This enables researchers to pinpoint where rubbish is coming from and what types of plastics are most common. "Without data, it's like fighting

against a problem that we don't understand," says Inty Grønneberg, CEO of Ichthion. The recovered plastic, up to 80 tonnes a day, is then sorted and sent off for reuse and recycling.

The first Azure systems are due to be installed next year in rivers in Ecuador, where it's

hoped they will stem the flow of plastic heading towards the Galapagos Islands.

Another device that the Ichthion team is working on will attach to ships and filter plastic particles from the water, an idea inspired by basking sharks that sieve plankton through their gills.

Inty Grønneberg with part of the Azure system, which will sweep plastics from rivers without harming wildlife





## BREEDING TOUGHER REEFS

Coral reefs are thriving ecosystems, with one-quarter of all marine species calling them home. But if average temperatures rise by 2°C by 2100, most of the world's reefs will be destroyed. Breeding 'super corals' could be one way of saving them from the climate crisis. In Australia, Prof Madeleine van Oppen is continuing the work she began a few years ago with coral biologist Ruth Gates, who died in 2018. She, and other teams of researchers, are trying different techniques that fall under the umbrella of 'assisted evolution', ranging from selective breeding to gene editing.

Some species of coral are naturally better able to cope with heat, and there are

already promising results from cross-breeding these tougher corals with other species to produce heat-tolerant hybrids. Meanwhile, scientists are hunting for the genes that give some corals their heat tolerance. Ultimately, the aim could be to replant reefs with hardy, lab-grown corals.

Conservation scientist Dr Heather Koldewey, from the Zoological Society of London, warns that we don't have time to conduct decades of research but urgently need to assess which solutions are most viable, so we're ready to act. But until countries cut greenhouse gas emissions, "everything else we're doing for coral reefs is just buying time," she says.

ABOVE Prof Madeleine van Oppen (right) and Line Bay are creating tougher corals that could cope with changing ocean conditions

RIGHT A researcher prepares coral samples in the lab



## SHARK EYE IN THE SKY

In Australia and South Africa, shark nets are often deployed in coastal regions to reduce the likelihood of shark attacks – not by putting a barrier between humans and sharks, but by deliberately killing thousands of sharks a year. The theory is that fewer sharks mean fewer attacks. However, as top predators, sharks are an important part of the ecosystem, and many species are already threatened. The nets can also trap other vulnerable marine life, including stingrays, dolphins and turtles.

Project Airship could provide a cost-effective, zero-impact alternative means of keeping bathers safe. Project Airship uses tethered blimps that are equipped with motion-sensitive cameras to keep an eye on coastal waters. According to founder Kye Adams, these blimps will keep going all day, as opposed to coastguard-driven drones that can only run for around 20 minutes.

During two test seasons in Australia, Adams deployed ‘analogue sharks’, otherwise known as human freedivers, into the sea. He was pleasantly surprised by how well the camera detected the divers swimming underwater with their arms stuck out to imitate a shark’s pectoral fins. The next step will be to use artificial intelligence to automatically detect real sharks. Ultimately, the airships could be an option to reassure swimmers and surfers that it’s safe to go into the water, rather than killing sharks by launching culling campaigns and setting up shark nets.

Kye Adams  
hopes that his  
Project Airship  
will stop shark  
culling and the  
deployment of  
shark nets



PAUL JONES/UNIVERSITY OF WOLLONGONG, GETTY IMAGES



## POLICING POACHERS FROM SPACE

Until a few years ago, it was almost impossible to track illegal fishing activity that was taking place out in the open ocean. What happened beyond the horizon, stayed beyond the horizon.

Since 2016, the Global Fishing Watch has been keeping an eye on the oceans from space. The collaboration between internet giant Google, the conservation group Oceana and satellite technology experts SkyTruth, makes it much harder for vessels to hide what they're up to.

The technology is based on the tracking devices that large boats must carry to broadcast their location, speed and course in order to avoid collisions with other vessels. The Global Fishing Watch team used this publicly-available information to teach computer algorithms what different types of fishing looks like. For example, long-lining boats work

over and over straight stretches of water, while trawlers crawl around more haphazardly. Now, the system analyses 60 million data points each day to identify the telltale fishing patterns of more than 65,000 vessels. The fishing activities are then posted in near real time on an interactive, online map that anyone can access and download. Already, governments are using the data to combat illegal fishing inside marine reserves, while researchers are drawing up strategies for making legal fishing more sustainable.

The system can even identify fishing vessels that are trying to dupe the system. The algorithms detect when several vessels use the same identification number, or when someone tampers with the onboard GPS and the vessel's broadcast location doesn't match the whereabouts of the satellite that received the data.



## SEND IN THE ROBOTS!

The deep sea is the planet's biggest habitat, but we still know so little about it. With emerging threats such as deep-sea mining, it has become increasingly urgent to study this habitat so we can find out what species live down there and what impact our actions will have.

The problem is, it's incredibly difficult to explore the ocean depths, but technological innovations, including fleets of diving robots known as autonomous underwater vehicles or AUVs, are helping us make this a possibility. Equipped with high resolution cameras, AUVs are the powerful eyes that allow us to glimpse the environment beneath the surface. The only snag is that somebody has to pore through the footage afterwards. "It's astronomical how long it takes to analyse imagery," says Prof Kerry Howell, a marine ecologist from Plymouth University. Howell leads the Deep Links project, which recently tested artificial intelligence as a way of speeding up the process.

Her team took a dataset of 150,000 images collected by one of the UK's AUVs, called Autosub6000, from a dive it made to more than a kilometre deep on the Rockall Bank in the Atlantic Ocean. PhD student Nils Piechaud got the unenviable job of examining 1,200 of those images and identifying 40,000

animals from more than 100 species. Using those images, he then trained Google's TensorFlow – a deep learning algorithm – to identify deep-sea animals. The algorithm's performance was then tested using other images it hadn't already seen. "For some species, it does very well," says Howell. Over 90 per cent of the time, the algorithm correctly spotted xenophyophores, organisms that look like croquet balls made of honeycomb.

It's early days, but Howell is convinced that algorithms will assist researchers with mind-numbing tasks and help unlock the potential of autonomous technologies. "The brilliant thing about artificial intelligence and computer vision is that it's consistent," says Howell. Unlike humans, algorithms don't get tired, or make unpredictable mistakes.

Of course, machines aren't always right, but their bias can be quantified and removed from the data – something that's impossible with the wandering minds of humans.

**ABOVE** Boaty McBoatface is an AUV that explores the deep sea with the British Antarctic Survey

**BETWEEN** This deep-water starfish was spotted by Plymouth University's AUV and has only been seen a handful of times

UNIVERSITY OF PLYMOUTH X2, ALEX MUSTARD/NATURE PICTURE LIBRARY



# PART TWO

DRUGS, FOOD AND OXYGEN... HERE IS WHAT WE STAND TO LOSE IF WE FAIL TO PROTECT OUR OCEANS

Corals, like the ones spawning here, are a promising source of new drugs

## AN UNOPENED MEDICINE CHEST

Modern medicine is becoming threatened by antibiotic-resistant infections such as MRSA. With lifesaving drugs losing their efficacy, some experts warn of a return to the Dark Ages if this continues.

As a consequence, an urgent search is underway for new medicines to battle against resistance, and one place people are looking is in the oceans. "Sponges and corals are the most promising sources of natural products that have medical properties," says Prof Kerry Howell, a marine ecologist from Plymouth University. That's because these

animals are commonly colonised by bacteria that have evolved chemicals to defeat and kill each other, making the ideal basis for antibiotic drugs.

As a deep-sea biologist, Howell is among the first to know about any new molecules discovered in the oceans. Howell and her colleague Mat Upton, a microbiologist also at Plymouth University, have already uncovered at least one molecule extracted from deep-sea bacteria that seems to be effective against MRSA.

Howell admits that she originally became interested in bioprospecting as a way of persuading people to

care about deep-sea species. "If you don't care about the deep sea just because it's wrong to destroy species and habitats, then at least care about it because it might actually save your life," she says.

It's not only antibiotics that are being found in the oceans. Painkillers have been produced that are based on the toxins of deadly, tropical cone snails. Meanwhile, a Caribbean sponge has yielded various antiviral and anti-cancer drugs, including cytarabine to treat lymphoma and leukaemia, and aciclovir used against shingles, chickenpox, cold sores and herpes.

# OCEANS THAT SOAK UP HEAT AND CO<sub>2</sub>

Without the oceans, the climate crisis would already be far worse. This huge volume of water has absorbed more than 90 per cent of the heat from the warming atmosphere, and soaked up many gigatonnes of carbon dioxide (one gigatonne = a billion tonnes).

A recent study calculated that between 1994 and 2007, the oceans absorbed close to one-third of all the CO<sub>2</sub> emitted by human activities. "The oceans have shielded us from the heat, they've shielded us from the carbon dioxide," says Dan Laffoley, from the International Union for the Conservation of Nature. "If the ocean hadn't been there, global surface temperatures would be over 30°C warmer."

He describes the oceans as a comfort blanket that has been keeping conditions just right for life on Earth. But while their colossal absorption of carbon and heat helps to stave off the climate crisis, it causes other problems beneath the waves. The oceans themselves are noticeably warming and are becoming more acidic, and as temperatures rise the oceans are losing oxygen.

And this spells bad news for all sea life, which will find it harder to breathe and survive. The shifting chemistry of the oceans makes life especially tough for corals, clams, plankton and other organisms with shells or skeletons made of calcium carbonate which begins to dissolve as pH drops.

The oceans protect us from heat and CO<sub>2</sub> generated by human activity. But for how long can this continue?



GETTY IMAGES, SCIENCE PHOTO LIBRARY, FESTO

# THE LUNGS OF THE PLANET

We should all be thankful for the existence of phytoplankton. Multitudes of these tiny organisms float through the oceans, harnessing energy from the Sun via photosynthesis, and in the process producing roughly half of all the oxygen in Earth's atmosphere (the rest comes from land plants).

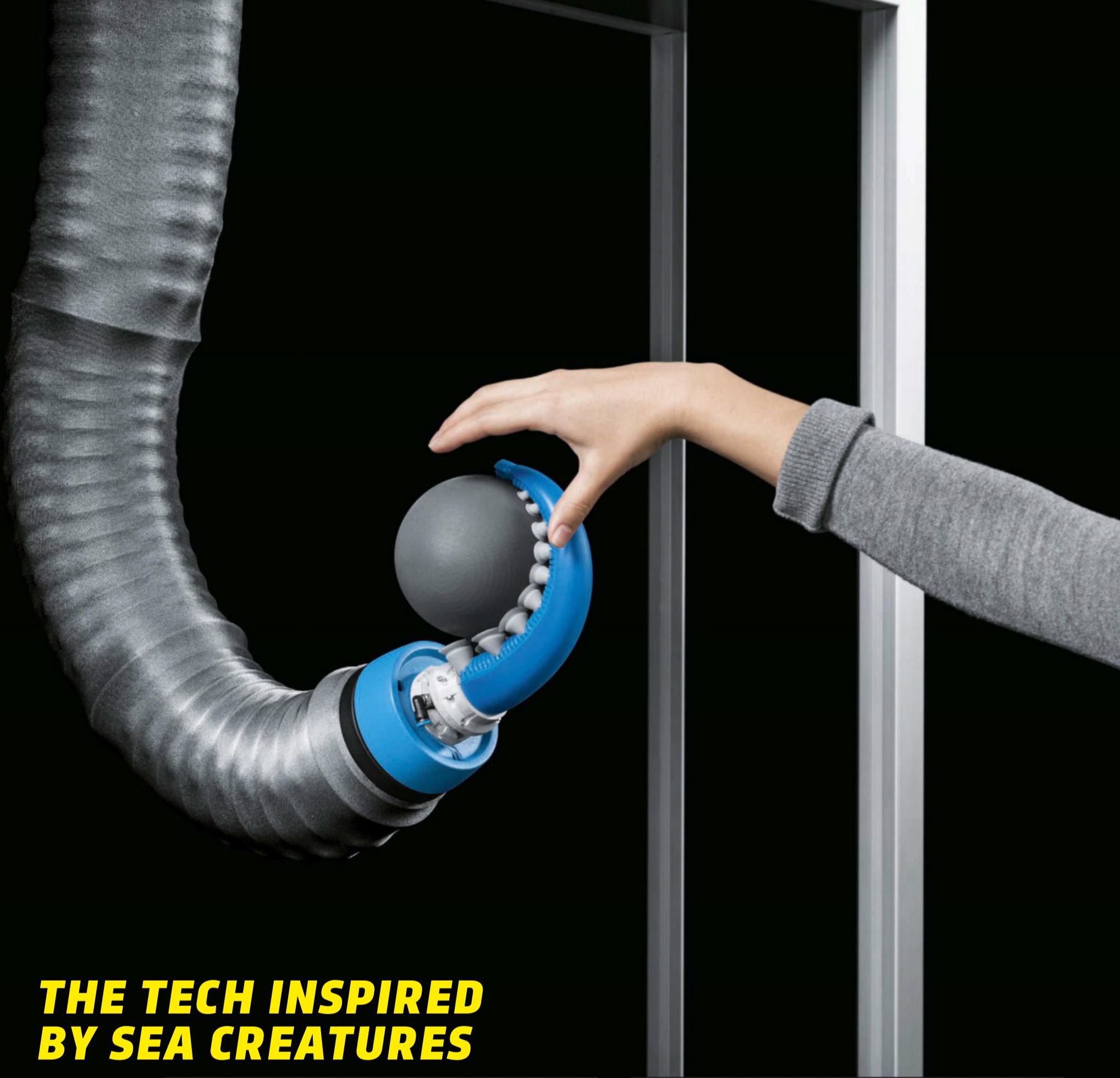
Especially important is a type of cyanobacteria, or blue-green algae, called *Prochlorococcus*. What they lack in size – 10 of them could fit across the width of a red blood cell – they more than make up for in numbers, and are probably the most abundant photosynthetic organisms on the planet.

"They exist in such numbers that they're measured in octillions, which I think is 10<sup>27</sup>, a ridiculously massive number," says Dan Laffoley, from the International Union for the Conservation of Nature.

*Prochlorococcus* specimens were first isolated from water collected from the Sargasso Sea in 1986, by oceanographer Sallie Chisholm from the Massachusetts Institute of Technology. This year, she was awarded the \$750,000 Crafoord Prize for her groundbreaking discovery and ongoing study of the vitally important cyanobacteria.



Enjoy breathing? You can thank these *Prochlorococcus* specimens



## THE TECH INSPIRED BY SEA CREATURES

This robot built by German company Festo was inspired by octopus tentacles

Many scientists and engineers have been inspired to develop useful new materials, structures and technologies based on the things that live in the oceans. For example, instead of clunky, metal robots, we could one day see soft-bodied machines inspired by the flexible arms of octopuses. Octopuses' amazing ability to change the colour and texture of their skin to instantly match their surroundings is also being investigated for use as military camouflage.

Inspiration from the oceans can come from the humblest animals. For example, researchers wanted to know how mussels stay attached to rocks, even when they are wet and being pounded by waves. It turns out that the molluscs secrete a special type of waterproof glue, which medical researchers are now using to develop surgical adhesives to use in intricate procedures, such as operating on unborn babies.

A relative of mussels – the limpets – posed another question that was only recently answered: how do these common shoreline molluscs spend so much time scraping algae from rocks without smashing their teeth? Their secret lies in the intricate nanostructure of their gnashers, which makes them the toughest known biological material. If a limpet wanted to, it could chew its way through a bulletproof vest. Their tiny, resilient teeth could be replicated and used to our advantage for manufacturing tough materials.

Sea urchins take the concept of impressive dentistry a step further with their self-sharpening teeth. Their teeth are made of layers of calcium carbonate crystals and organic material with specific weak points that snap, leaving a razor-sharp edge. If materials scientists can mimic that ability, we could find ourselves using urchin-inspired, self-sharpening scissors and knives.



## AN IRREPLACEABLE SOURCE OF FOOD

According to the World Wide Fund for Nature (WWF), approximately three billion people rely on seafood as their number one source of protein. Just under half of the fish we eat comes from wild animals caught in the oceans, with the rest coming from fish farms. Besides the familiar fish and shellfish, the oceans provide something else that reaches into our diets and daily lives, often without us knowing it. Each year, at least 25 million tonnes of seaweed are farmed.

Sometimes you'll see it as the nori wrapped around your sushi rolls, but a lot of it is used to make industrial products, including alginates and carrageenans, which end up in all sorts of items. Shampoo, toothpaste, pet food, ice cream, processed meats, vegetarian hot dogs, beer, shoe polish, air fresheners and fire extinguishers can all contain chemicals derived from seaweed.

Seaweed farming has traditionally been carried out in Asia, and now

other countries including the UK and US are catching onto the benefits. Not only is seaweed considered a 'superfood' that's rich in iodine, calcium and amino acids, but it can be sustainably farmed and is carbon-neutral, absorbing carbon dioxide and mopping up excess nutrients from the sea. Seaweed can be used to create biofuels, while research suggests that cattle reared on seaweed-based feeds produce less methane, a potent greenhouse gas.



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## IT'S TIME FOR ACTION

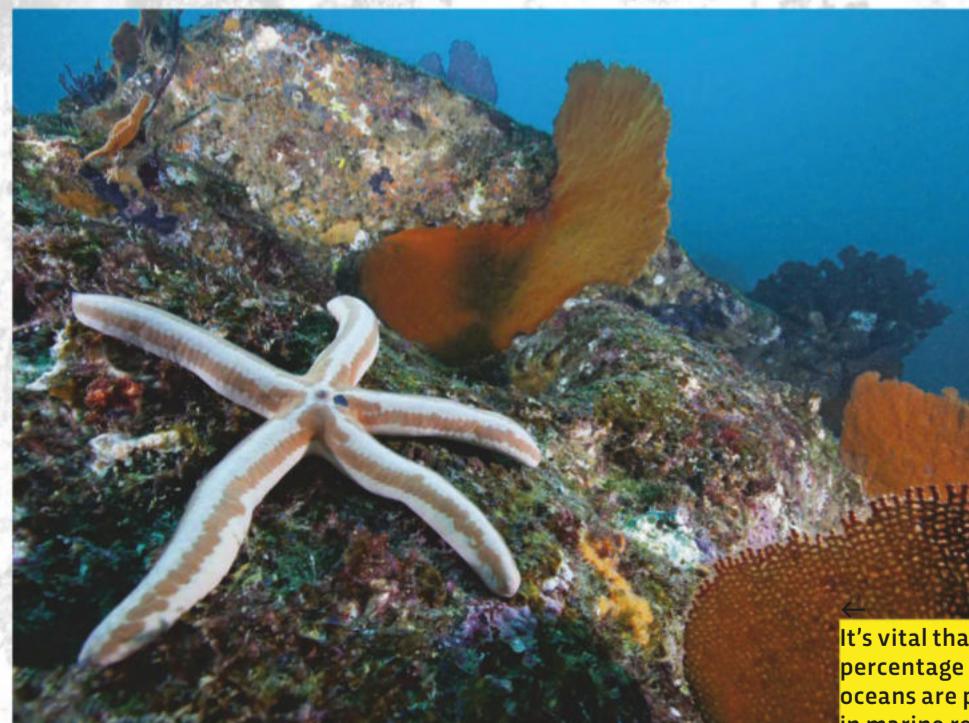
Given everything they provide and all the ways they make planet Earth habitable, it's crystal clear that the oceans urgently need safeguarding. Establishing marine reserves where all damaging activities are off limits – particularly fishing – is a major win-win for the oceans and for us: ecosystems become healthier and potentially more resilient to climate change, while fishing is boosted by the eggs and larvae of species that spill out from these thriving oases.

Currently, around 8 per cent of the world's ocean area has some level of protection inside marine reserves, although many are considered to be good on paper, but not well-enforced.

The European Commission claims that 10.8 per cent of European seas are protected, but a recent World Wide Fund For Nature (WWF) report concluded that properly managed reserves only cover 1.8 per cent. A global target to protect 10 per cent of the oceans by 2020

looks to be within reach, but conservationists and scientists are demanding more. In 2016, members of the International Union for the Conservation of Nature (IUCN), including 1,400 governments, NGOs and indigenous communities, voted overwhelmingly in support of a new target: protect 30 per cent of the oceans by 2030. This will help support fisheries, encourage biodiversity and safeguard traditions linked to the oceans.

"There's no scientific publication that supports the current policy of protecting 10 per cent," says the IUCN's Dan Laffoley. Science is telling us that the minimum needed is one-third protection of the oceans, or more. And it's not just about marine reserves but also what happens outside them. "If we are to have a sustainable ocean," says Dr Heather Koldewey, a senior advisor at the Zoological Society of London. "It has to be a combination of protection combined with sustainable management of the rest." SF



by DR HELEN SCALES  
(@helenscales)  
Helen is a marine biologist and science writer. Her latest book is *Octopuses*, from the *Ladybird Expert Series* (£8.99, Michael Joseph).



INTERVIEW

# A HISTORY OF DANGEROUS IDEAS

The recent BBC Four series *Eugenics: Science's Greatest Scandal* showed us how scientists played a part in the idea that selective breeding could make a superior human race. Co-host **ADAM PEARSON** spoke to **AMY BARRETT** about making the documentary and discovering what his life would've been like as a disabled man in Britain in the early 20th Century...



X

**“I always say that there are two kinds of people in this world. Disabled people, and people who will be disabled. I’m sorry that’s not the happiest note in the world to bring up, but it’s completely true”**

#### WHAT IS EUGENICS?

Eugenics is the idea that you can make the human race genetically better by keeping good and desirable genes in the human gene pool, and taking bad ones out.

It started with Francis Galton, Charles Darwin’s cousin. So, I think a lot of his thinking in its roots is Darwinian. But Darwin died before the word ‘eugenics’ was even coined.

#### WHAT DETERMINES WHAT GENE IS ‘GOOD’ AND WHAT GENE IS ‘BAD’?

Well, this is the real crux of not only the programme but the whole issue. I don’t think anyone really has the right to say what genes are and are not good, particularly when it comes to disability and hereditary. What we now know to be true, and what was thought to be true back in the early 1900s, are miles apart. In probably another 50 years, what we know to be true now will be laughable folklore to future scientists.

#### WHAT DID THE SCIENTIFIC COMMUNITY HAVE TO SAY ABOUT EUGENICS IN THE EARLY 1900s?

They were very much in favour of it. It was a case of ‘we’re making the human race better and this will make a better future for everyone concerned’. This was a well-respected science. It’s well documented that Churchill was a eugenicist. Virginia Woolf was a eugenicist... it wasn’t like it was some crackpot, cultist theory that just stemmed from fiction.

There’s a really haunting Virginia Woolf comment where she’s walked past a line of ‘imbeciles’ and says, “It was horrible, and it would surely be better if they were all put to death.” That was just a regular thing to write down or say. Whereas, if I threw that up on Twitter now, I’d be for it.

#### BUT WE NOW KNOW MORE ABOUT WHAT IS AND WHAT ISN’T DETERMINED BY OUR GENES...

Absolutely. The examples of good genes that [eugenicists] said was in a family, [we know now they] aren’t genetic components. The idea that because you’re from an athletic family, you’re therefore an athlete is ridiculous. If I was LeBron James’s son but all I did was sit on my arse playing Xbox all day, I’m not going to make it into the NBA in any way, shape or form.

Scientists have spent years looking at educational achievements, trying to find a pattern between attainment and DNA. They have found genetic

markers could partly explain how well a person could do at school, but of course a correlation between two things doesn’t mean one causes the other. These markers might not be related to intelligence, but be more common in more well-off families, who can afford better education.

#### GALTON MADE OTHER CONTRIBUTIONS TO SCIENCE, THOUGH. HE WAS A STATISTICIAN AS WELL AS A EUGENICIST.

Oh, Galton was by no means an idiot. But with most scientists, like most people, your greatest triumphs pale in comparison to your greatest flaws or greatest mistakes. No one talks about standard deviation when you hear about Francis Galton, though it was his conception. They always jump to eugenics and those darker things.

I’m not just saying “Ah, Francis Galton, damn you!” I understand what else he did for science and that he has a body of work outside of eugenics. Though eugenics is very much his legacy, it’s a very, very long footnote at the end of an amazing scientific career.

#### GENETIC EDITING COULD ONE DAY GIVE PARENTS THE ABILITY TO SELECT FOR CERTAIN TRAITS, LIKE BLUE EYES, OR EDIT AWAY TRAITS THEY BELIEVE TO BE UNDESIRABLE. COULD THIS MARK A RETURN TO EUGENICS?

I don’t think eugenics as we knew it, and as Francis Galton designed it. Certainly not in the UK.

I think the rhetoric that surrounds gene editing and CRISPR is what causes a lot of the alarm and hysteria. We hear the term like ‘designer babies’... that’s never going to happen. The science just isn’t there. There’s also a whole wing of science called bioethics, whose sole job is to stop it happening.

Occasionally you get a scientist that will go rogue, like the guy in China who genetically edited babies to be HIV-resistant. But he’s now under house arrest and is essentially a wanted man.

#### ADAM PEARSON

Adam is a broadcast journalist, actor and disability rights activist. He has been involved with campaigns such as Changing Faces, a charity to support those with visible difference to their body. In 2013 he starred alongside Scarlett Johansson in the sci-fi film Under The Skin, with the hopes of changing the stigma around people with a disfigurement. His Horizon episode My Amazing Skin documented Adam and his twin brother Neil’s experiences of living with neurofibromatosis type 1 (NF-1).



**LEFT** Adam Pearson and co-host Angela Saini investigate the murky world of eugenics in *Eugenics: Science's Greatest Scandal*

Outside of that, those kind of things are very few and far between.

**SO, IF 'DESIGNER BABIES' AREN'T A THING, WHAT ISSUES ARE THERE WITH PRENATAL TESTING FOR CONDITIONS?**

I'll use the most common example of Down's syndrome. Scientists have isolated the two genes that cause the heart defects that are one of the more serious complications that come with Down's. If they can repair those two, they're not screening out Down's altogether. They're simply mitigating one of the more severe complications that can come with it. Which I think can only really be a good thing.

However, termination rates following prenatal screening for Down's syndrome are really high. When I read the literature that they give parents who have a positive test for Down's... to me, it paints the picture that having a child with Down's is a death sentence. It's not kind of warm or fluffy at all, it's worded like a Stephen King novel. What does that say about how we treat these kinds of people? Are we as far removed as we think we are from the olden days of asylums and forced sterilisation?

For people like myself with hereditary conditions, we have the ability to scan for faults in embryos. They can remove the bad embryos, the

ones that carry the gene causing the condition, to leave only the good ones. It's an option, but it's not one that people are forced to take.

It isn't going to eliminate disability altogether, because that's not how genetics or disability works. With the genetic component of a disability, there will always be examples of random, spontaneous mutation, and there are things outside of genetics that contribute to disability.

I always say that there are two kinds of people in this world. Disabled people, and people who will be disabled. It's coming for all of us. I'm sorry that's not the happiest note in the world to bring up, but it's completely true.

So, when we have conversations about prenatal testing for genetic conditions, we're also talking about the people in society living with those conditions.

**A LOT OF IT IS DOWN TO THE FAMILY, TO HAVE THEIR OWN CONVERSATIONS ABOUT WHETHER THEY WANT TO PASS ON A GENETIC CONDITION. IT'S NOT FOR ANYONE ELSE TO STEP IN.**

No, no. Eventually I'll have to sit down with Lady P, the future Lady Pearson, and have the chat. It doesn't necessarily haunt me, but it's something that I knock around in my head. Will I have the testing? Will I not have the testing? Even outside ➤

• of that, there are other options. I've got a good friend who does a lot of fostering and adoption. Those are certainly things I'd consider.

In all, you know, I'll make it work, even if we do go down the *au naturel* route. Nothing's the end of the world. I crushed it and my kids are going to crush it. My kids are going to be genetically awesome. That will mostly be their mother, though.

**YOU REFER TO THE 'BAD EMBRYOS', WHICH ARE THE ONES CARRYING THE GENETIC CONDITION. THAT'S THE KIND OF LANGUAGE THAT PEOPLE ARE USING AT THE MOMENT TO REFER TO DISABLED PEOPLE.**

I know, I know, and I find myself using it all the time. But I don't want to make the language wishy-washy, I don't want to start making things too wordy. We both dilute the science and make communication really difficult.

We think the language now is complex – it was even worse back in the day. One of the things we look at [in the programme] is the Mental Deficiency Act of 1913, where people could be legally classified as kind of morons, idiots and imbeciles. [The Act was repealed in 1959.]

There's a place that we visited in the first episode called Meanwood Park. That was the first of dozens of asylums for those classed as mentally impaired in the UK. It was huge. It was like a military operation, almost. They kept the sexes apart to stop people breeding. Forced sterilisation had been outlawed in the UK way before this. So, that was how they did it.

We interviewed Harvey Waterman, who was certified under the Mental Deficiency Act at the age of four. Harvey was locked up for 29 years at another asylum called St Lawrence's, where men and women were also segregated. Harvey said every now and again he'd be allowed to go to a dance, where they were watched like hawks.

There wasn't a lot that shocked me [in recording the documentary], but when we met Harvey that is the one time where I had to pretend to need the toilet and go and, kind of get myself back together. That's the first time I've ever had to walk out of an interview, rebalance oneself and come back out.

**WHAT WAS IT ABOUT MEETING HIM THAT WAS DIFFERENT?**

The story. What happened to this man, this human being. He lost everything. His freedom, his dignity, his future. We've just heard a speech from a teenager [Greta Thunberg] saying, "You've stolen my childhood and my dreams." Hold it up to what happened to Harvey, and then come back to me.

Also, just the sheer weight that permeated the whole early part of the programme: this would have

**"Nothing's the end of the world. I crushed it and my kids are going to crush it. My kids are going to be genetically awesome"**

been me. No 'could have been me', no 'might have been me'. They'd have come for me, without doubt.

**IT IS SO SHOCKING TO THINK ABOUT WHAT WOULD HAVE HAPPENED JUST 100 YEARS AGO.**

Oh yeah, yeah. I would have definitely been in some kind of paddock in the middle of nowhere with 'my kind' just doing menial work. It would be really easy to get arrogant and think, "Oh no, I'd have rebelled." No. No one rebelled. That was the quickest way to get some kind of arse-kicking in those kind of environments.

So, yeah, I think we have come a long way. The debate I want to have is, have we come as far as we think we have, attitudinally, towards disability? Or can we be doing more?

Saying you don't lock disabled people up any more and saying we accept all people as equals in society are two very different statements.

**ARE WE NEARLY THERE?**

Ah, we're getting better. Disability is now on people's radar a lot more than it was. As long as we keep having discussions and we keep the drawbridge down, then that progress will continue.

My fear now, even outside of the whole eugenics area, is that we make things way too sensitive and start pulling people up on language, which is maybe a bit less relevant in the grand scheme of things. That will slowly bring the drawbridge back up. You need to give people room to get the words wrong and lovingly and graciously correct them. As opposed to jumping on the old social media and using loads of hashtags to make a point.

**BECAUSE THAT CAN THEN DRAW LINES BETWEEN US, IT CAN BE 'THEM AND US' AGAIN.**

Absolutely. And then we are right back to square one. **SF**

**DISCOVER MORE**



Watch Eugenics: Science's Greatest Scandal, available on BBC iPlayer.

# SCIENCE OF SOUND

**CONSTANT  
INNOVATION  
IS DRIVING THE  
EVOLUTION OF  
MUSIC TECHNOLOGY  
TO IMPROVE  
YOUR LISTENING  
EXPERIENCE**

*Music technology has come a long way since Thomas Edison unveiled the first phonograph in 1877. In the almost 150 years that have followed, we've seen formats come and go; we've seen recorded music enter the home and then leave it, thanks to portable music players; we've even witnessed recorded music's medium change from a physical form to a digital one.*

*But one thing hasn't changed: people's desire to get the very best from their music technology. Which is where this guide comes in. Inside, we'll introduce you to some of the most innovative audio equipment available today and explain exactly how it could take your listening to the next level.*

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# SOUND WITHOUT SACRIFICE

**Do you know how much of the music is missing when you listen to MP3s?**



**AudioQuest's DragonFly boosts your playback device to deliver better sound**

ow much are you willing to sacrifice for the sake of convenience? A little? A lot?

It all depends on the circumstances. But if you like to stream your music through any sort of digital device, you're probably compromising more than you imagine.

Popular streaming services, such as Spotify and Apple Music, offer unrivalled convenience: they provide you with instant access to millions of songs but that convenience comes at a cost - sound quality.

In order to provide such a vast range of music to everyone, streaming services distribute it using MP3 and AAC files; two formats that are very small and therefore

very convenient for storing, transmitting and playing digital music files. But while these formats are capable of delivering a song in a recognisable form, they're simply not big enough to contain all the sound quality of the original recording.

A significant amount of the sound quality from the original recording of that song - the

version that musicians, producers and sound engineers intended for you to hear - has to be sacrificed in order to cram it into an AAC or MP3 file. In some cases, as much as 90 per cent of the data from the original recording is discarded. What that leaves you with is a music file that can be streamed instantly but has less sound quality than a humble CD.

If that strikes you as too much of a sacrifice to be making for the sake of convenience, then there is a solution: the MQA, or Master Quality Authenticated, format. MQA is a

technology that enables all of the original recording to be preserved in a digital format that can still be easily streamed.

MQA works with the record labels to ensure the original master files are authenticated and encoded in MQA, employing a sophisticated technique to ensure that all the sound quality of the original studio recording reaches your ears. It's a similar process to the way a zip file works on a computer -

**The convenience of streaming music comes at a cost: sound quality**



all the data is packaged so it can be kept in a smaller space, instead of having to ditch data to reduce the file size.

Simply put, MQA allows you to enjoy the convenience of streaming music without having to sacrifice sound quality. But perhaps most importantly of all, you can switch to streaming MQA files without having to replace your existing music equipment.

You can stream thousands of MQA tracks on your computer or via an iOS or Android device from Tidal. While the Tidal app decodes MQA music files, you can further enhance playback by using a high-performance digital-to-audio converter (DAC), such as one of the three USB-based models that make up AudioQuest's award-winning DragonFly range. Plug a DragonFly into your smartphone or computer, then plug your headphones into the DragonFly and you can enjoy the dynamic, detailed, high-definition sound that MQA can deliver. You can also plug into your Hi-Fi using a simple cable.

The original AudioQuest DragonFly appeared in 2012. Three years later, in 2015, it was superseded by the DragonFly Black and DragonFly Red - a pair of 'plug and play' USB DACs that, to this day, continue to offer audiophiles unprecedented sound quality at more affordable prices.

DragonFly Black, the entry-level model, outputs 1.2 Volts courtesy of its high-quality headphone amp and analogue volume control, making it ideal for driving in-ear monitors. It costs just £89. DragonFly Red is a more advanced

device that's capable of outputting 2.1 Volts, enough to drive more sophisticated headphones. Red retails for £169.

DragonFly Cobalt however, is AudioQuest's new flagship USB DAC, which won Best DAC under £350 from What Hi-Fi in its 2019 awards. Cobalt sits at the top of the DragonFly family tree thanks to its ability to deliver naturally beautiful, seductive sound while entirely eliminating the fuzz and fog that so often overshadows digital music files.

Cobalt has a robust 2.1-Volt output to drive almost any headphone; it uses a bit-perfect digital volume control for outstanding signal-to-noise ratio; its PIC32MX274 microprocessor draws less current and increases processing speed by 33 per cent; and it's compatible with Apple and Android devices. In short, Cobalt is an exceptionally competent and affordable MQA Renderer. And it can be yours for just £269.

With MQA audio files and an AudioQuest DragonFly USB DAC, you'll be able to enjoy music with all of the convenience and none of the compromise. All three DragonFly models help deliver beautiful sound to earbuds, headphones, desktop speakers or complete audio systems. The pairing of MQA and AudioQuest ensures you no longer have to sacrifice sound.

#### TO FIND OUT MORE

visit [mqa.co.uk](http://mqa.co.uk) & [audioquest.com](http://audioquest.com)



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**Below, recording artist**  
**Jake Isaac listens to**  
**his recordings in MQA**



# PUT MUSIC AT THE HEART OF YOUR HOME

**Great sounds, voice-activated  
multi-room control and a virtual  
assistant all in one**



**Harman Kardon's Citation speakers  
do more than just play music, they  
become the hub of your smart home**

hen is a speaker not a speaker? When it's part of Harman Kardon's Citation series of smart home audio systems. In which case it's a wireless, internet-enabled, voice-activated virtual assistant that combines an engaging listening experience with transfixing design.

Every speaker in the Citation series has Google Assistant built in to not only enable hands-free control of your home's music, lighting and heating systems but also allow you to access your schedule, check weather and news reports, and find information online, all without touching a button.

But while all of that is an unquestionably useful addition, it's not the *raison d'être* of a speaker. The purpose of any speaker is to play music. Except when it's a Harman Kardon speaker, that is; in which case its purpose is to play music with exceptional HD quality. And that's exactly what every speaker in the Citation series does. Each model - from the £179.99 Citation One all the way up to the £2,199.99 Citation Tower - delivers a dynamic listening experience, with deep and distortion-free bass.

Combine music and smart home control with  
Harman Kardon's Citation speakers

Citation speakers come in a range of shapes, sizes and power outputs to suit your needs, whether it's a small model that can sit discreetly on a shelf or a large pillar that's part of a surround sound system as well as a commanding piece of design. But one thing all Citation speakers share is Bluetooth and Chromecast connectivity so you can wirelessly play or stream music from your smartphone, tablet or computer (Citation 300 and 500 models also support streaming via AirPlay2).

Individually, every Citation speaker delivers exceptional audio to whatever room it's in but, when used in combination, Citation speakers can bring both multi-zone and multi-room audio to your home - so you can share your music throughout your house or allow everyone to listen to their own preferred music, all through one networked Citation system and all in exquisite quality.

Harman Kardon's Citation series blends innovation with attention to detail to provide practicality with sublime sound for the discerning listener.



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# EXCELLENCE REMASTERED

**Introducing the all-new Mu-so 2nd  
Generation - the premium wireless  
speakers your music deserves**



looks can be deceiving. The new Mu-so 2nd Generation wireless music system family from British Hi-Fi specialist Naim Audio may resemble its predecessors but the comparison barely stands up to the lightest scrutiny. The Mu-so 2nd Generation and Mu-so Qb 2nd Generation aren't merely updated versions of their forebears, they're the next evolution of them.

Both models have been comprehensively reengineered. They've benefitted from extensive software and hardware upgrades that enable them to deliver a significant performance boost over the

original award-winning Mu-so range, which launched in 2014.

The new Mu-so 2nd Generation family features Naim's unique music-streaming platform, developed by 25 engineers over three years to offer the very best performance, whether the source is your own digital music collection, internet radio or an online service such as Spotify. This acclaimed innovation is only found in Naim music-streaming products, from its entry-level Uniti range, all the way up to the £20,000 flagship ND 555.

Both of the new Mu-so models are packed with power (450 Watts in the Mu-so 2nd Generation while its smaller sibling, the Mu-so Qb 2nd Generation, has 350 Watts) served up to all-new speaker drivers that have been optimised in collaboration with Focal, the acoustic specialist celebrating its 40th anniversary. Mu-so 2nd Generation speakers also have upgraded 'brains' in the form of a DSP that contains 10 times extra processing power for even greater musical accuracy.

Stream your music in high-resolution quality (the

speakers can handle files up to 32bit/384kHz) via UPnP™, or browse millions of songs through AirPlay 2 (including Apple Music), Spotify Connect, TIDAL, Chromecast and internet radio.

Mu-so 2nd Generation speakers work brilliantly on their own but can be easily integrated with others to create a multi-room set-up. By using the updated Naim app (available for iOS and Android devices) you can combine them with other networked Naim products (including 1st generation Mu-so and Qb). Alternatively you can pair Mu-so 2nd Generation models with other AirPlay 2-compatible wireless speakers via the Apple Home app, or with other Chromecast devices via groups controlled by the Google Home app.

“Combining our company's 46 years of Hi-Fi mastery with the very latest music-streaming technology, not to mention class-leading performance, features and design, Mu-so 2nd Generation speakers are the wireless audio systems you and your music deserve.”

Charlie Henderson, Naim Audio MD

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[naimaudio.com](http://naimaudio.com)



# MORE SIGNAL, LESS NOISE, NO POWER

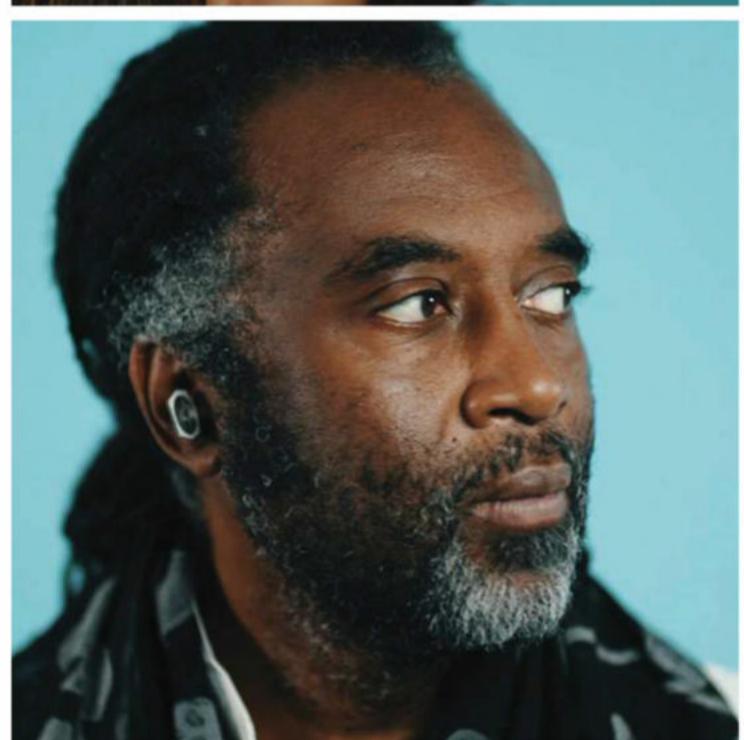
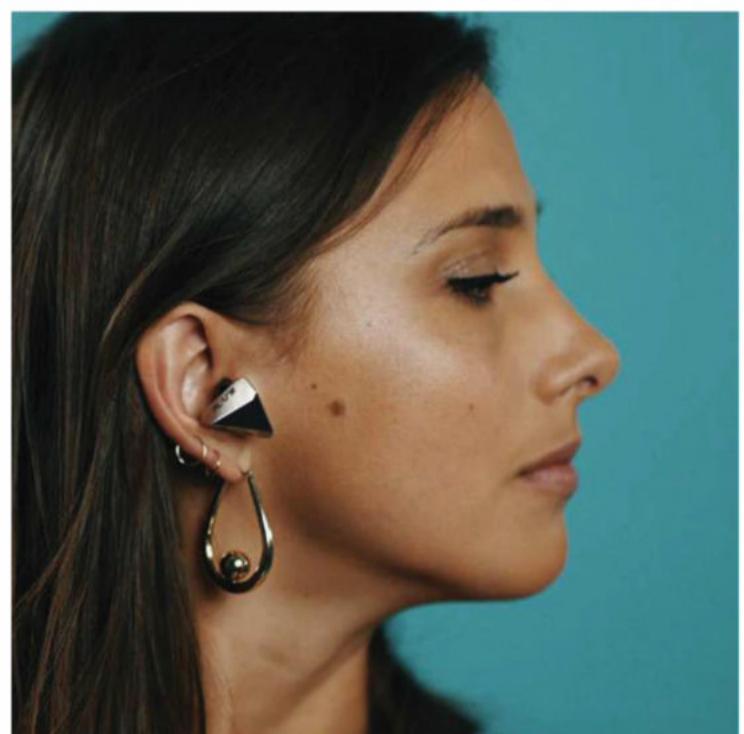
**Hear the world in high-definition,  
without the need for batteries**



**earHD gives you all the good  
vibrations, none of the bad**



**Hear live sound with more  
detail and clarity**



Most every piece of audio technology has two things in common: one, it's built to reproduce recorded sounds better; and two, it relies on a power source of some kind.

But what if you want to hear live music better? Or the sounds of nature? Or even just the person you're talking to? There are no devices designed to help you hear any of those with greater clarity and less distracting background noise. Not unless your hearing is already impaired in some way. And not without requiring batteries or a connection to the mains.

Or there wasn't, until now, because Flare Audio's new earHD have been specifically engineered to help you to hear in high definition.

earHD is not a hearing aid - it doesn't increase volume; what it does is increase detail. It's a passive (non-powered) hearing device that reduces distracting ambient noise so you hear more or what you want to listen to, and less of what you don't.

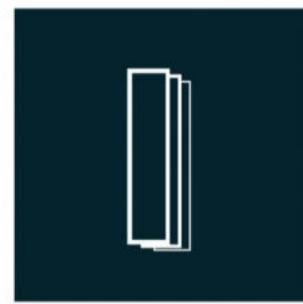
Because our ears are on the side of our head, they are brilliant at determining where sounds are coming from. But what we gain in sound location we lose in definition. Our ears are great at receiving quality sound from the sides and from devices such as headphones, as this sound travels straight into our ears. But when we want to hear sounds coming from in front of us - when we're at a gig or concert, for example - it has to compete with the sounds emanating from either side, which are naturally prioritised by our ears due to their shape and position.

But you can overcome nature with the help of earHD. earHD acts like a satellite dish to funnel in higher levels of detail from a 60°-wide aural field directly in front of you. It uses a precise acoustic lens to focus the sound uniformly and reflect it straight into your ear, while isolating that sound from the background noise outside of that aural field.

Or to put it another way, earHD ensures you hear more of the signal and less of the noise surrounding it. And independent tests carried out by the Institute of Sound and Vibration Research at Southampton University confirm it. You hear more with earHD, whether you're listening to live music or a loved one speaking to you.

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**FLARE.**®



“Mojo is the easiest way to integrate a pro-quality DAC into your everyday listening experience”

# SUPERCHARGE YOUR HEADPHONES WITH MOJO

**Put the power back in your music with the help of the device used by the best sound engineers**



In its natural state, sound – whether it's speech, song or music – is a physical phenomenon. It's a series of waves that travel through the air until they hit your eardrum. Your eardrum absorbs these waves and transmits them to your brain, which translates them into the words being spoken, the lyrics being sung or the notes being played. In its natural state, sound is analogue.

But sound in its natural state can only be heard once, in the moment it's made. In order to hear it again, the sound needs to be recorded, which means the physical phenomenon must be transformed into data. In other words, the analogue sound must be turned into a digital signal, which is what happens in a recording studio. Musicians and sound engineers use microphones and analogue-to-digital converters to capture the sound and transform it into a format that can more easily be stored, mixed and distributed – digital sound files.

Strictly speaking, you can't hear digital sound files; it's just data. Without a digital-to-analogue converter (DAC) it's just a series of zeros and ones. You need a DAC to take those digital zeros and ones and turn them back into the analogue soundwaves that your ear and brain can recognise.

The good news is that devices that play digital sound files – computers, smartphones and

tablets – come equipped with DACs. The bad news is those DACs are invariably inferior, mass-produced units that have been chosen because they keep costs down and not because of the conversion capabilities they offer. Which means the quality of the conversion is poorer so the sounds reaching your ear are less like the original sounds made by the singer or musician.

You can remedy that, however, by using a dedicated, high-quality DAC, such as Chord Electronics' Mojo. Mojo is not only the world's most advanced portable DAC/headphone amplifier, it's also the easiest way to integrate professional-quality digital-to-analogue conversion into your everyday listening experience – whether you're at home or on the move.

It's the DAC award-winning sound engineers like Mike Crossey, Dom Morley, Tim Young, Tony Cousins and Stuart Hawkes turn to when they're in the studio because they know it delivers sound as the musician intended.

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Chord Electronics Ltd.

# LOSE YOURSELF

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*Audio  
Detail*



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chance to experience superior sound  
with the best equipment around**

reat music stirs the soul. It brings back memories and summons up your strongest emotions. The sounds of your favourite songs and symphonies are magical; they are sounds to get lost in. But that magic can only happen if the conditions are right.

If your speakers seem tinny, or the bass lacks depth, or your system simply can't reproduce the full spectrum of sound necessary to transport you to that other place, you're cheating yourself and your music.

For the magic to happen you need a system that can go the extra mile. But creating a set-up with that sort of capability



## Products that combine outstanding audio capability with visual flare

isn't magic. It's science, it's engineering, it's electronics, it's experience. And it's something that the people at Malvern Audio Research know all about.

Malvern Audio Research specialises in building bespoke music systems using the highest-quality, hand-made components available. Products that combine outstanding audio capability with visual flare. Products that have been specifically developed to be just a bit more special. Products such as the Horns collection of designer speakers, all of which make a statement that's both sonically and stylistically strong.

But also products like the Audio Detail and Ming Da ranges of valve amplifiers, which, thanks to improvements in transformer design and material specification, are capable of offering much wider bandwidths than their predecessors, while also delivering far greater clarity and none of the harshness

associated with their transistor-based equivalents.

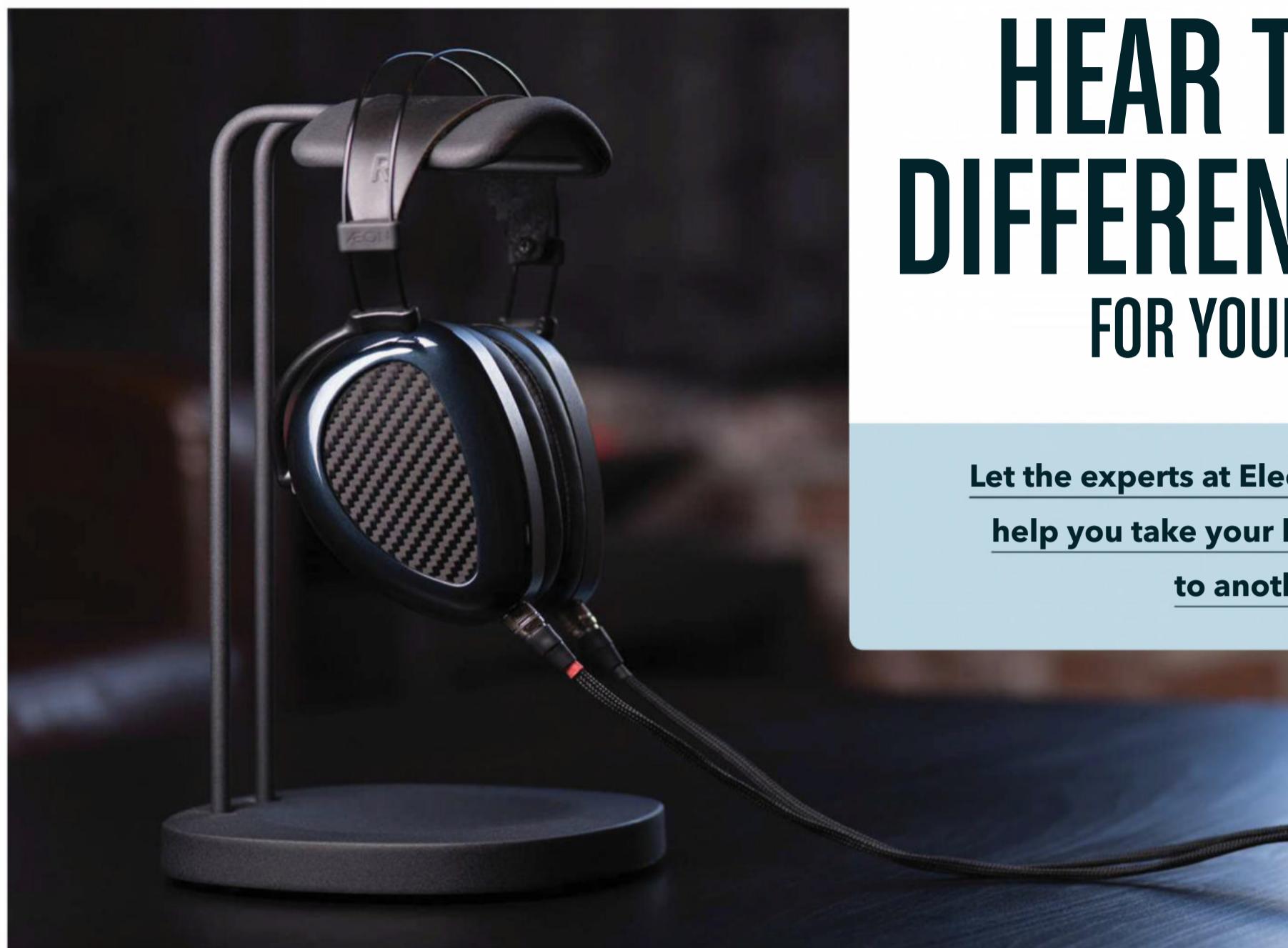
You can experience all of these products, and many more, by visiting Malvern Audio Research's Worcestershire HQ and booking a session in the company's Test Room. There you'll get to benefit from expert advice the team has to offer on constructing a superior system and hear how good your favourite artists sound when their performances are reproduced on the very best equipment. So what are you waiting for? Come and experience the magic for yourself and get lost in the music. We challenge you not to be moved!

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# HEAR THE DIFFERENCE FOR YOURSELF

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nyone can sell headphones. But it takes a genuine passion for sound and the subtly different ways it can be reproduced to be able to advise audiophiles on a set tailored to their specific needs. And that's exactly what you'll find at Electromod.

With a well-established reputation for sourcing cutting-edge products and unparalleled customer support, the team at Electromod offers experience, expertise and world-class service to audiophiles all over the world.

Electromod offers a wide range of amps, digital to analogue converters and headphones from some of the world's most innovative manufacturers, including Schiit Audio, Synergistic Research, Dekoni and MrSpeakers.

MrSpeakers is a relative newcomer to the audio equipment market but the San Diego-based company has quickly made a name for itself by producing a number of award-winning headphones. The most recent additions to

## Electromod – For headphones tailored to an audiophile's hearing

the MrSpeakers' collection are the Aeon Open and Aeon Closed headphones, which can trace their lineage back to MrSpeakers' earliest and now, sadly, discontinued models: the Alpha and Mad Dog.

When MrSpeakers discontinued their Alpha and Mad Dog headphones, they promised to deliver a variety of headphones to meet a wide spectrum of needs and budgets. The company's first efforts, the Ether and Ether Flow headphones collectively won more than 20 awards for performance and design.

Their second in-house designed headphone, the Aeon Open packs all the technology of Ether Flow headphones into a compact, comfortable and cost-effective design that delivers the best of Ether Flow sound quality at a more affordable price.

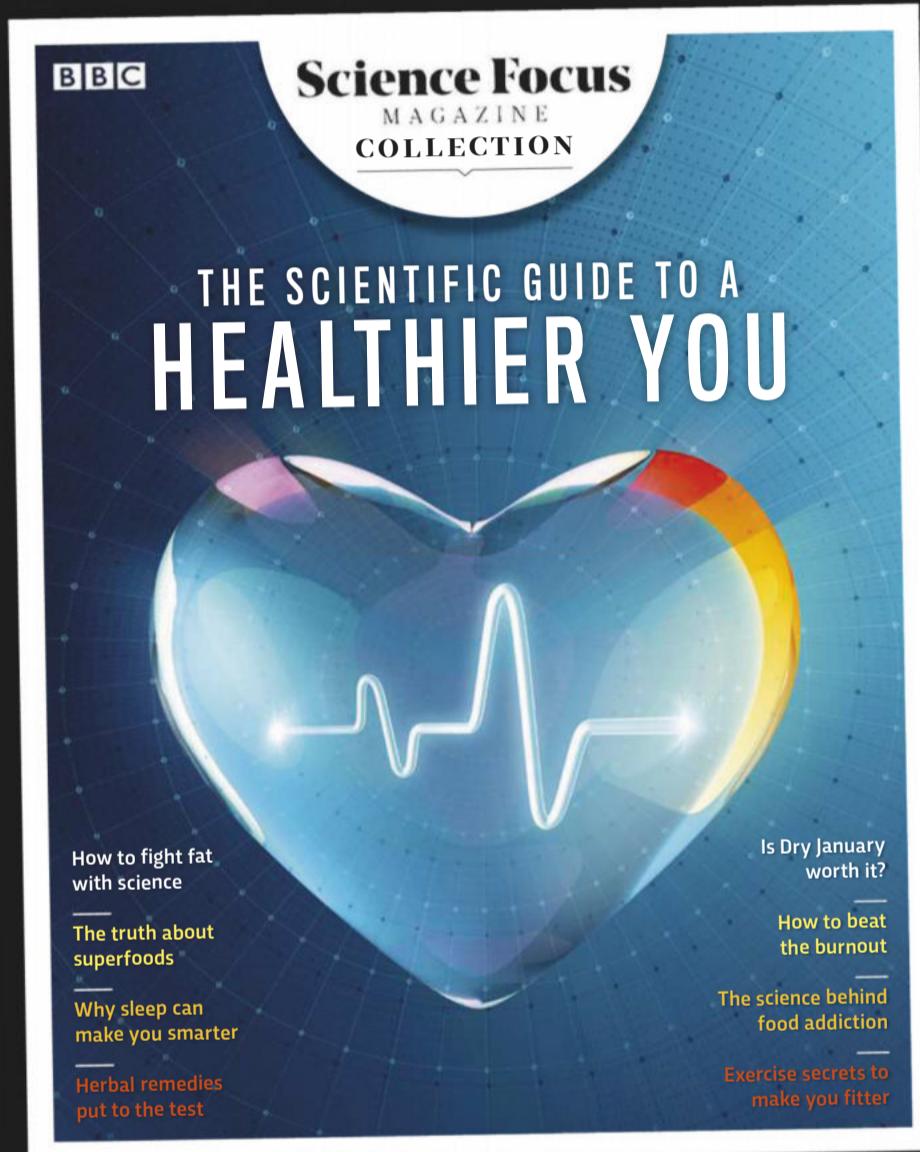
Both of the new Aeon models use MrSpeakers' preferred planar magnetic drivers,

which are said to offer greater fidelity than their dynamic counterparts. The Aeon Open is geared towards more expansive 'soundstage' environments, while its Closed sister model is better suited to busy and noisy locations. But both Aeon models offer incredible audio performance and stand apart in terms of sound quality and comfort. Come and hear the difference for yourself by getting in touch with the Electromod team today.

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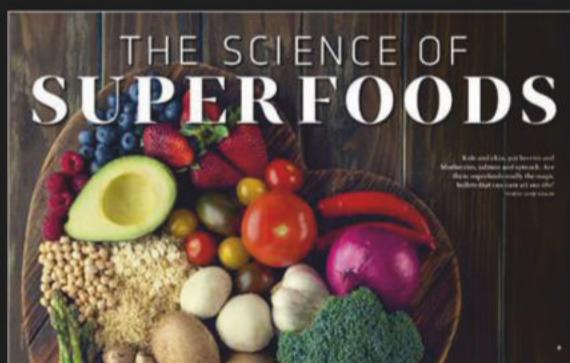
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# THE ROUTE TO HAPPY GUTS

Could a diet help ease the misery of bowel problems for millions of sufferers?

When I was young I travelled extensively and, because I was living cheaply, I got a range of interesting tropical diseases, including some exotic gut infections. More recently, I deliberately infected myself with tapeworm for the BBC Four programme *Infested*.

Despite all this, I have never had any long-term gut problems. Other people are not so fortunate. Gut problems are remarkably common, with irritable bowel syndrome (IBS) being one of the most common, affecting around one in five people at some point in their lives. Symptoms include stomach cramp, bloating, and either diarrhoea or constipation. It often gets worse in sufferers when they hit their 30s.

British doctors are not great at helping people with IBS, which is often dismissed as 'psychosomatic'. Although there is a psychological component to IBS, you may have heard that it can be treated – in the majority of cases – by going on a temporary, restricted diet called the 'low FODMAP diet'. There is an increasing amount of evidence that this diet can help people with IBS by altering the trillions of microbes in the gut.

Research shows that the mix of bacteria in the guts of people with IBS tends to be different from those of the average, healthy person. The result is that when someone with IBS eats certain foods, they blow up with gas. That's because they are feeding a

X

**"Bacteria in the guts of people with IBS tend to be different from those of the average person"**

host of 'bad' microbes that have taken up residence in their digestive tract.

FODMAP stands for 'fermentable oligosaccharides, disaccharides, monosaccharides and polyols'. These are the scientific terms used to classify carbohydrates found in many foods that are notorious for triggering symptoms such as bloating, gas and stomach pain. Doing a low FODMAP diet involves cutting down on sugars, refined starchy carbohydrates – those found in potatoes, bread and pasta – as well as dairy products, wheat, rye and most processed foods. You also

have to cut out a surprising number of 'healthy' fruits and vegetables, including apples, peaches, pears, cauliflower, leeks, garlic and onions. Excluding these foods for six to eight weeks lets the gut calm down. You can then reintroduce ingredients one at a time to see which ones are triggering the IBS.

The diet was developed by scientists at Monash University in Australia and research has shown that it can help to reduce symptoms in around 75 per cent of people with IBS (find out more at [monashfodmap.com](http://monashfodmap.com)). But it's not only IBS that can be relieved. A small study published by King's College in October this year showed promising evidence that a low FODMAP diet could even ease symptoms of inflammatory bowel diseases (IBD) like Crohn's and colitis. Clearly, more studies need to be carried out, but it's certainly an interesting time for gut research. SF



**MICHAEL MOSLEY**

Michael is a writer and broadcaster, who presents *Trust Me, I'm A Doctor*. His latest book is *The Fast 800* (£8.99, Short Books).



## COMMENT

# ONLY HUMAN

Let's stop ripping people apart for making careless mistakes in the online world

A friend of mine is currently at the centre of a vicious internet storm. It's one of her own creation, a momentary lapse that swirled into a typhoon, as the online world is wont to do. It'll blow over, but I'm shocked at how quickly the winds picked up, and how unprotected my friend was.

I've seen such things before, but only from a distance: the woman who tweeted something inconsiderate before boarding an airplane, only to discover upon landing that it went viral; the scientist who made a public announcement about a huge scientific achievement while wearing a shirt that some found offensive; the leader of a country who's had to grapple with the discovery of ancient photos that he wishes hadn't seen the light of day. These moments of unthinking can barrel into huge, life-changing events with just a few clicks.

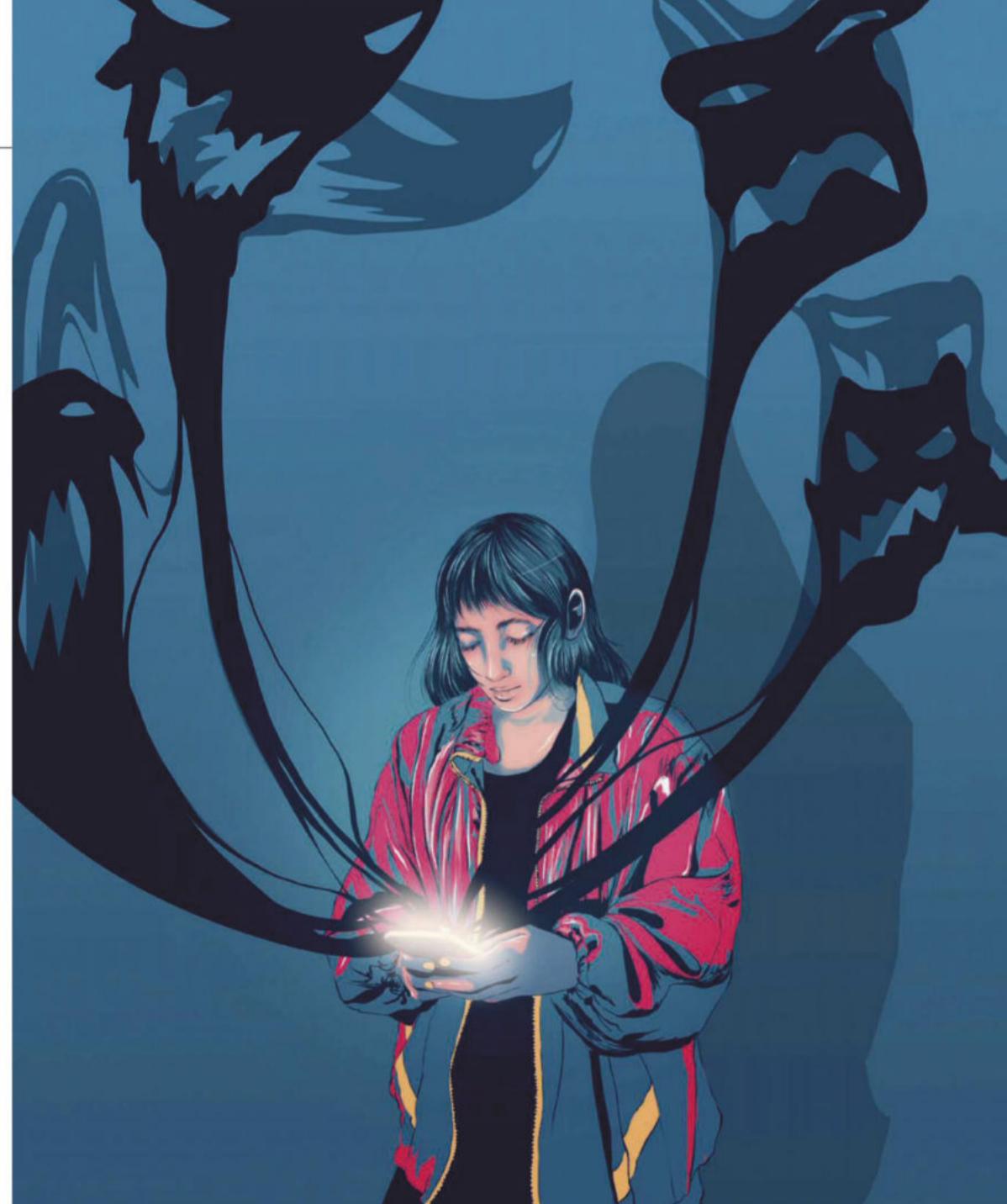
But we can't ban the internet for causing these storms – it's our fault, too. We love to pass judgement – while some of us try to rise above it, it's part of our psychosocial development. Think of headlines that direct us to feel one way or another about an inept celebrity caught in the headlamps. These headlines cast characters we can judge ourselves against: the forlorn partnerless woman, the predatory *femme fatale*, the enviable yet malleable man at the centre of a girl fight. These modern fairy tales serve to calibrate our moral compasses.

X

**"I don't think all the time – in fact I've been known to be pretty careless. I'm not proud of it, but I am human."**

The problem is that these characters and our reactions to them are entirely cultural and local, so when we combine this with the digital network, there's bound to be a clash. Our tiny brains cannot fathom how many people we might be tweeting at, and so we think we are speaking to that intimate group we think is just like us, who'll get the joke and keep it discreetly to themselves. Not so in the internet age.

Now that the moral magnifying glass is in the hands of people like you and me, those who overstep the mark are fair game. But we're doing two things. First, we're condemning the person who made the misstep to



being forever defined by that error. Yes, they said something stupid, but maybe they just didn't think. I don't think all the time – in fact I've been known to be pretty careless. I'm not proud of it, but I am human. We've been loose-lipped on the internet for just two decades: it'll take some more digital citizenship lessons for it to truly bake in.

More crucially, the second thing we're doing is creating a forum that defaults to aggression. If we continue to be on the defensive, jumping to conclusions, we will forget nuance, context and human fallibility.

Watching the internet eviscerate my friend feels like I'm witnessing one of Margaret Atwood's 'particicutions': pointless and the product of a totalitarian system. A far cry from what the internet's founding fathers imagined their brave new world to be.

So next time you see something uncomfortable online, take a breath. Remember that people make mistakes. And perhaps your public response isn't 'raising awareness', but creating a world where we're antagonistic rather than compassionate by default. SF



**ALEKS KROTOSKI**

Aleks is a social psychologist, broadcaster and journalist. She presents *Digital Human*.





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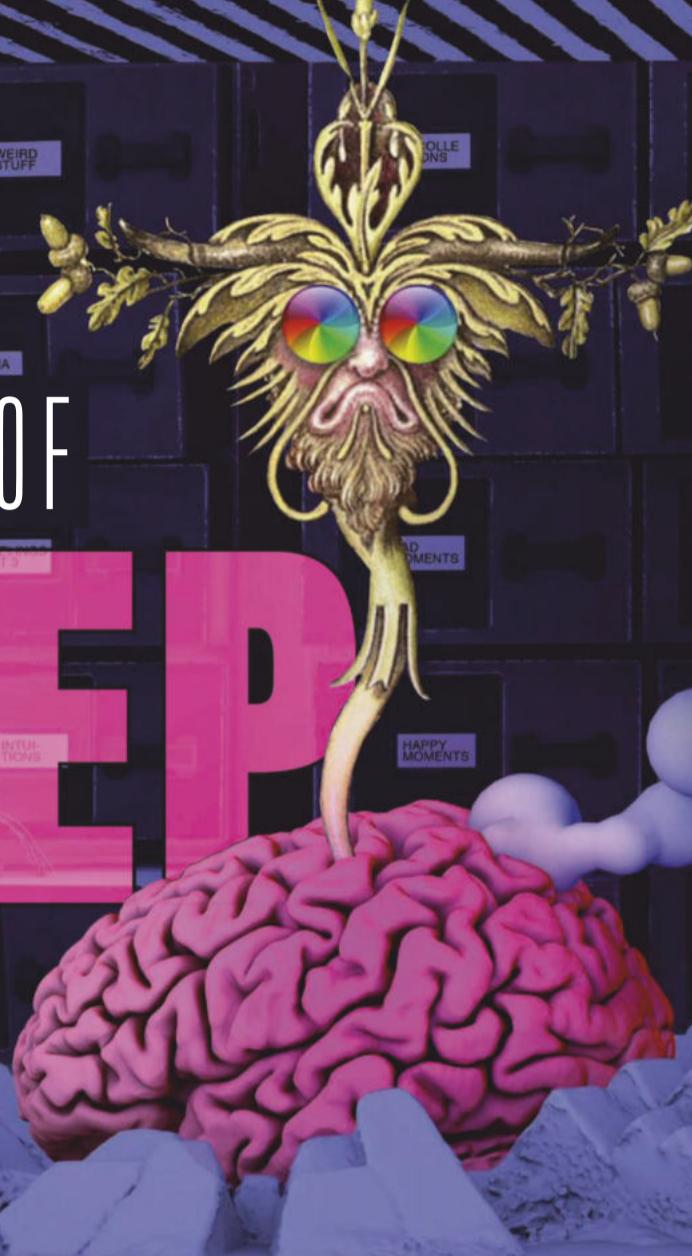
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THE MYSTERIES OF

# SLEEP



**The clocks have gone back, leaving many of us reaching for the coffee as our body clocks struggle to realign. But there are many aspects of sleep that still leave experts scratching their heads...**

Words **Ginny Smith**

Illustrations **Victor Soma**

## HOW DID SLEEP EVOLVE?

Imagine two animals, of the same species, living in a dangerous environment where food is scarce. Animal A spends the day searching for food and mates, while avoiding predators. When night falls, she rests, remaining still but watchful until daybreak. Animal B follows the same pattern, but while resting, she becomes unconscious, and almost entirely unaware of the world around her. Which animal do you think would have the best chance of survival?

If you answered A, congratulations! You have discovered the paradox that surrounds the evolution of sleep.

Debate rages over why all but the simplest of animals have evolved to spend so much of their lives unconscious. One idea is that sleep conserves energy, but studies have shown we burn almost as many calories snoozing as we do when we are awake, so that seems unlikely. Evolution tells us that if something is a risk, as sleep is, then there must be a benefit outweighing that risk. So what is the

benefit that sleep brings?

Decades of research have linked sleep with memory processing, emotional stability and even the brain's 'rinse cycle'. But what we don't know is whether we sleep because these processes need to happen, or whether we evolved to carry them out while sleeping because it's more efficient than doing them during the day.

What's clear is that the Earth has a rhythm, a cycle of light and dark, and almost all animals have their own circadian rhythms, or body clocks. Most set them based on light levels, but even blind cave fish in Mexico, which have lived underground for millennia, have body clocks.

Dr Andy Beale, a postdoctoral scientist at the University of Cambridge, studies these animals. He says that every cell in the body has a rhythm, so it is vital for organisms to have a way to sync these, even if they don't use the Sun to do so. So perhaps sleep arose as a way to group the body's processes, ensuring that cells all carried out their maintenance simultaneously, rather than in conflict with one other.

Unfortunately, however, evolutionary theories are hard to prove, so for the moment we are left wondering how sleep emerged in the first place.

**"SLEEP IS A RISK, SO THERE MUST BE A BENEFIT THAT OUTWEIGHS THAT RISK"**



## WHY IS SLEEP DEPRIVATION DANGEROUS?

A handful of families appear cursed. Around middle age, many of the members develop strange symptoms: sweating, tremors and – most troublingly – complete and devastating insomnia. These are signs of an extremely rare disease called Fatal Familial Insomnia (FFI).

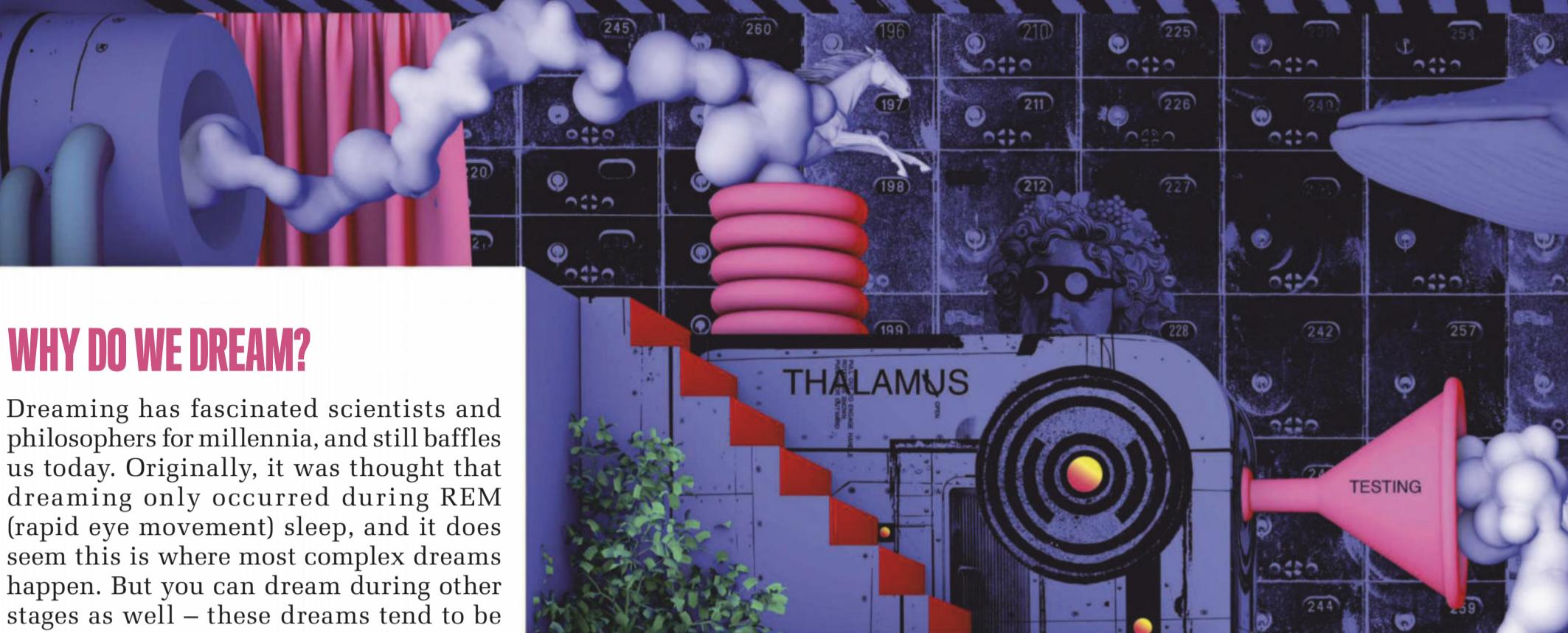
A genetic mutation in FFI sufferers causes misshapen proteins to build up in the brain, damaging the thalamus – the control switch between wake and sleep. Without this brain area, sleep is impossible. And without sleep, sufferers fall into a kind of waking coma. From the onset of their symptoms, they rarely live longer than a year.

While there are many theories about why we need sleep, how sleep deprivation can kill you is still a mystery. But a recent study may have found a clue. Researchers discovered that cells in the brains of sleeping mice shrink, allowing cerebrospinal fluid – the colourless liquid that circulates in the brain and spinal cord – to flow more easily, sweeping away debris that builds up around active cells during the day. This is carried to lymph glands and flushed out of the body. So perhaps sleep is vital because without it, these toxic by-products build up in the brain.

The idea that sleep cleans up our brains is hard to test, and studying people with FFI can't give us all the answers. We can't even know for sure if it's the sleep deprivation itself, or the brain damage that causes it, that kills sufferers. Animal studies provide another clue. Experiments have shown that sleep-deprived rats die within a month, but again, proving lack of sleep killed them is tricky – it could instead be the stress of being repeatedly woken.

The longest recorded period of wakefulness in a healthy human is 11 days, by student Randy Gardner. By the end, he suffered declining cognitive functions, mood swings and even hallucinations. Despite this, he recovered within a day or two, and didn't experience any long-term health problems. But he might not have been fully awake for all 264 hours. Research has shown that sleep-deprived humans experience 'microsleeps', of which they are unaware. These can last for just microseconds, and can even happen in one part of the brain while the person is 'awake' and functioning.

So can sleep deprivation kill a healthy person? Or will the brain fight back to protect itself? The answer is, we just don't know...



## WHY DO WE DREAM?

Dreaming has fascinated scientists and philosophers for millennia, and still baffles us today. Originally, it was thought that dreaming only occurred during REM (rapid eye movement) sleep, and it does seem this is where most complex dreams happen. But you can dream during other stages as well – these dreams tend to be more like snapshots, associated with strong emotions. But why do we do it?

One idea is that dreaming helps with sleep's memory-processing function. After learning a maze, the brains of sleeping rats activate the same neurons they used during the day, as if they were practising or reliving the maze. We think the same happens in humans: in fact taking a nap, particularly if it includes REM sleep, can improve problem-solving abilities. During sleep, our brains sort through information taken in during the day, decide what to store, and make connections between new facts and memories. It is possible that dreams help with this, which might explain why dreaming about recent experiences is common, but also why dreams often involve weird links that your waking brain would never make.

Another theory is that dreams help with emotional processing. When we first store a memory, the associated emotions are vivid, but over time they lessen. This is why losses and traumas become more bearable with time (unless this process is disrupted, as in PTSD). Perhaps dreaming helps this dissociation, by allowing memories to be processed and removing some emotional associations.

Alternatively, dreams may provide a safe way of testing the brain's reactions to negative or threatening events, which might be why dreams are often emotional. By practising running away from a dream monster, you know what to do if it happens in real life!

Or it might be sleep that is important, and dreams are just the by-product of a brain starved of external input – like a screensaver on your computer. Interestingly, some drugs suppress REM sleep, and patients report fewer dreams, but don't seem to experience any negative effects... so the mystery of dreaming lives on.

## IS BEING A NIGHT OWL BAD FOR YOUR HEALTH?

Another mystery is why some people bounce out of bed at 7am, ready to face the day, while others repeatedly hit the snooze button before stumbling blearily towards the coffee pot.

This is the question being studied by Dr Sam Jones, a sleep researcher at the University of Exeter. By investigating the genetics and behaviour of around 700,000 people, he and his team discovered more than 300 genes that seem to play a role in making you a morning or evening person. But your disposition isn't set in stone. Previous research suggested only about 25 per cent of whether we are early-rising 'larks' or evening 'owls' is down to our genes.

"It looks like it's predominantly habitual and environmental," Jones says. "It's not genetics that determines your 'chronotype' to a great extent, but your habits, your lifestyle, what you eat, how much stimulation you get in the evening, etc. It seems to be rather a modifiable thing."

As well as understanding the chronotypes themselves, Jones investigates how they affect people's lives, and early research provides tantalising hints. For example, evening people seem to be more likely to develop schizophrenia later in life. And careful analysis shows this isn't just down to genes having multiple effects – something about living the owl lifestyle puts you at greater risk of the illness. On average, owls also have lower wellbeing and are more likely to develop depression. We don't know for sure why this is, but Jones believes it probably isn't being an owl itself that is damaging – it is trying to fit in to a society that's set up for larks. This means owls are experiencing constant jet lag, which may put their bodies and brains under stress. Because of this, some people are promoting the idea of a more flexible working day. But until further research is carried out, we don't know whether this will actually improve the lives of owls, or make them less likely to suffer health problems.

# WHY DO SOME PEOPLE NEED LESS SLEEP?

We've all met them. People who do more in a day than seems humanly possible. When asked their secret they smugly say, "I only sleep for four hours a night – it's all I need," with a superior look on their face. But do they really only need half the sleep most of us do? Or are they storing up problems for later life?

In 2009, researchers led by Prof Ying-Hui Fu from the University of California, San Francisco, found that carriers of a particular gene slept for two hours less than non-carriers, on average. But then they discovered a family with three generations of short sleepers who *didn't* carry this gene. By sequencing their genomes, the team discovered another mutation that appeared to be linked with short sleep. And mice bred with this same genetic change were easier to wake. These natural short sleepers don't seem to suffer from the health problems normally associated with getting so little sleep.

But a note of caution here. The new study investigated a single family, and a team led by sleep researcher Dr Sam Jones at the University of Exeter has come across the same mutation but found no link to sleep length. Jones and his team are writing a paper to challenge Fu's results, although Jones agrees that natural short sleepers do exist.

"It does look like some people might get away with less sleep, simply because of genetic factors which predispose to shorter or longer sleep," he says. "I think there's probably a limit, maybe somewhere between six-and-a-half to eight hours, but any more than that, I would be doubtful."

Again, genetic factors are likely to play only a small role, and environment is vital too. It may be that short sleepers are actually *efficient* sleepers. Most people don't spend all night in deep, restorative sleep. Racing thoughts delay dropping off, or you might be awoken by noise, light or your bladder. Eating late or drinking alcohol before bed can reduce sleep quality, and staring at screens might have an impact too. Perhaps these people aren't amazing in their ability to sleep *less*, but in their ability to sleep *well*.

This doesn't make them any less worth studying, however. In fact, it might make them more important. We don't know why some people fall asleep the moment their head hits the pillow, while others spend hours tossing and turning, or why some can sleep anywhere, anytime, while others need pitch-black perfection to get a moment's shuteye. Perhaps learning more about these short, efficient sleepers could help us all improve the quality of the sleep we get each night. **SF**

by **GINNY SMITH** (@GinnyFBSmith)

*Ginny is a freelance science writer and presenter, with a background in psychology and neuroscience. She presents the British Psychological Society's PsychCrunch podcast.*

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**BBC**  
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MAGAZINE



# WHAT IF

WE JUST  
FORGOT ABOUT  
FASHION?

WORDS:  
HAYLEY BENNETT

THIS NEW SERIES EXPLORES THE RUNAWAY CONSEQUENCES OF HYPOTHETICAL QUESTIONS.  
IF THERE'S SOMETHING YOU'D LIKE US TO ANSWER, GET IN TOUCH AT [REPLY@SCIENCEFOCUS.COM](mailto:REPLY@SCIENCEFOCUS.COM)

*Fact: fashion is bad for the planet. So what would happen if we banned it entirely?*

Every year, the fashion industry uses over 79 billion cubic metres of water – about as much as gushes over the top of Niagara Falls annually – and pumps out 1.5 billion tonnes of CO<sub>2</sub>, not far short of the transport emissions of the US. For many, though, fashion

is pure pleasure. We love shopping for it, wearing it, and posting pictures of it on Instagram. So what would we save and what would we lose if we defied the fashion gods and thought only about function? What would change in a fashion-free world?

1

# The planet would look fabulous, dah-ling!

Ditching fashion would lift a huge burden off our planet. We'd save water (used in crop-growing and dyeing processes) and carbon dioxide emissions (from the industry's energy use). And we'd also prevent pollution from the fertilisers and pesticides used in cotton farming, and hazardous chemicals used in dyes.

The sheer scale of our 'fast fashion' habit is mind-boggling. In Europe, we hang 6.4 million tonnes of new clothes in our wardrobes each year; US consumers now stuff in a new item every week.

"Wearing clothes is one of those fundamental needs that we all have as humans," says Dr Mark Sumner, a fashion and sustainability researcher at the University of Leeds. "So from a population point of view, the fashion industry is huge."

Industry is only half the problem, though. Consumer behaviour, driven by advertising and social media, is also to blame. We can reduce our fashion footprints by donating old clothes and buying secondhand, but Sumner says that not enough of us do this – we're too obsessed with 'newness'. Another fashion foible is washing clothes when they're not dirty, which shortens their lifespan and releases more microfibres into waterways (as many as 700,000 fibres per wash), where they can harm marine life.

There's no question that a planet without fashion would be a healthier planet – if we all went starkers, we'd be over a billion tonnes better off in terms of CO<sub>2</sub> emissions alone. But, thinking practically, we'd probably still need to protect our modesty...





## 2

# We'd all wear onesies... or eco-sweatpants

In the 1999 film *The Matrix*, the humans of circa 2199 wear scruffy, undyed, woolly jumpers – the fashion fallout of a war. Banning fashion today could result in a similar look. Government-issue coveralls might be a choice for today's onesie-wearers, although if you can't bear all the unzipping for toilet breaks, how about a pair of eco-sweatpants?

Organic cotton could be an environmentally-friendly fabric for our eco-pants. However, Sumner says we might need to rethink our definition of 'organic'. While synthetic fertilisers and pesticides are banned by organic certifications, which emphasise alternatives like compost and natural pesticides, there are no limits for water consumption. Meanwhile, growers in the Better Cotton Initiative (BCI) – the world's biggest cotton sustainability

scheme – focus on key principles such as soil health, biodiversity and sustainable water use, but don't ban the chemicals that some find unacceptable. "It's swings and roundabouts with these different models in terms of what we think is right," says Sumner. "But a huge amount of work has been done [on] trying to find ways to reduce some of the environmental harm of growing cotton."

Sourcing sustainable cotton would provide employment for some of the hundreds of millions of people who currently work in the textile and garment-making industries. There'd also be jobs in the synthetic fibre sector: our eco-sweatpants would need polyester for sweat-resistance, and we could harvest this from old plastic bottles. Leave it undyed, with matching sweatshirt, and you have casualwear fit for dystopia.

## 3 We'd have an identity crisis... or toe the line

What we wear says a great deal about us – our social standing, our music preferences, even our personality. But there's a tension between individuality and wanting to belong, according to Dr Maria Mackinney-Valentin at the Royal Danish Academy of Fine Arts, and author of *Fashioning Identity*. "Even though we are telling our own story, we are always doing it within socially acceptable contexts," she says.

On the one hand, we want to stand out – difficult in a world with no fashion. But the devil can be in the detail. Prisoners and soldiers change the lacing on their shoes or turn up their collars as tiny expressions of individuality. Schoolkids flout uniform rules.

Particularly interesting is the case of North Korea, where jeans, miniskirts and colourful fabrics are restricted by the authoritarian government. Many people have just a couple of sets of clothes, and most avoid looking different.

According to a 2018 study, this is mainly to dodge the disapproval of their compatriots, with people imposing pressure on each other to dress the same. But the study also describes the experiences of 11 female defectors to South Korea. The women experienced a profound 'culture shock' around fashion and identity, especially about the amount of skin on show. They tried to 'learn' South Korean fashion so they wouldn't stick out.

So do we really just want to fit in? Perhaps in a fashionless future, eco-uniforms would provide a sense of cohesion and wellbeing? Not for Sumner, who likens the scenario to an Orwellian-style "horror story", where, as in the novel *1984*, everyone walks around in overalls. "The main character talks about this idea that he doesn't have any self-identity; doesn't have any self-esteem," says Sumner. "That's where we'd end up if fashion didn't exist."



## 4

## There'd still be class differences

Historically, fashion has never been a great class leveller. So if Meghan Markle, you and I were all slouching around in the same unbranded sweatpants, wouldn't society be more equal? In Elizabethan times, there were rules about what colours and fabrics you could wear, and how big your ruff could be, depending on your societal status. Earls, knights, barons and their eldest sons enjoyed velvets and gold fabrics, whereas the less wealthy were forbidden by law from 'excesses of apparel'.

Today, like the Elizabethans, we covet luxury items as a display of our wealth and status over others. A 2017 study by researchers in Australia concluded that the brand-conscious fashion buys of women aged 19 to 34 are driven by a desire for status and uniqueness. Meanwhile, a 2018 study identified an 'Abercrombie & Fitch effect', whereby men who were greeted by an athletic-looking male shop assistant bought items that were on average twice as expensive as those bought by women in the assistant's presence, supposedly to gain dominance.

So what would happen if luxury brands didn't exist, and our wardrobe was standard-issue? While it's nice to think that we'd live in a more equal world, it's likely that the upper echelons would still find a way to assert their status. "I think it would be difficult to remove [fashion] completely, even if it was strictly regulated," says Mackinney-Valentin. So maybe a post-fashion world would go eco-Elizabethan, with the rich and powerful reviving the ruff.

5

## We'd unleash our digital selves



Could we perhaps forego the logos and luxury brands in real life, and get our fashion fix online instead? After all, digital fashion already exists: in the video game *Fortnite*, for example, users buy 'skins' which they pay for with real money. "You're showing your individuality through these skins, which are outfits," explains Mackinney-Valentin.

According to a 2016 study at the University of the Aegean in Greece, fashion in virtual worlds like *World Of Warcraft* and *The Sims* often performs the same function that it does in the physical one: it expresses

an identity but also, potentially, helps communicate to other users what sort of group you might belong to. Some people make their avatar's appearance similar to their real-life one, while others use customisation to achieve "a better version of themselves". Freed from restrictions of flesh and fabric, characters can be as extravagant as the imagination allows, with clothing that pulsates with colour or animations.

Perhaps if we had nothing but beige sweatpants to share on Instagram, we'd all start using such avatars on our social media profiles,

or even take them to virtual offices. You could log into a conference call from your sofa, wearing your eco-sweats, but show up onscreen in a gold power suit. "That makes sense," says Mackinney-Valentin. "What a relief! You wouldn't have to think of what to wear every morning."

Never mind the apocalypse, let's do it anyway. **SF**

ILLUSTRATIONS: VALENTINKACH

by HAYLEY BENNETT  
(@gingerbreadlady)

Hayley is a freelance science writer and editor, working in her sweatpants in Bristol.

BBC

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# ALL YOUR QUESTIONS ANSWERED

GETTY IMAGES

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astrophysicist

**ALEX FRANKLIN-CHEUNG**  
Environment/  
climate expert

**ALOM SHAHA**  
Science teacher,  
author

**DR PETER J BENTLEY**  
Computer  
scientist, author

**DR HILARY GUISTE**  
Former GP,  
science writer

**CHARLOTTE CORNEY**  
Zoo director,  
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Oceans expert,  
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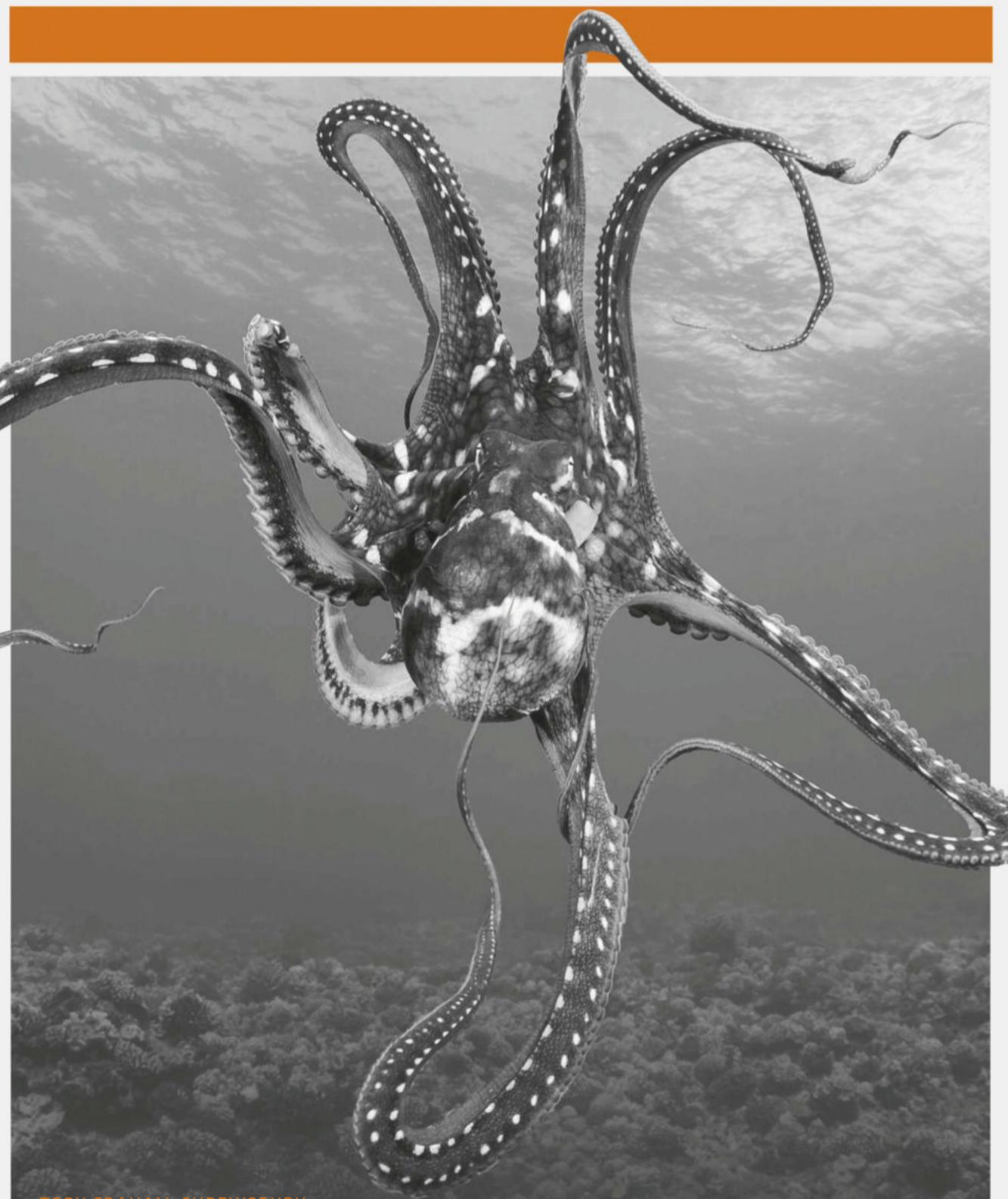
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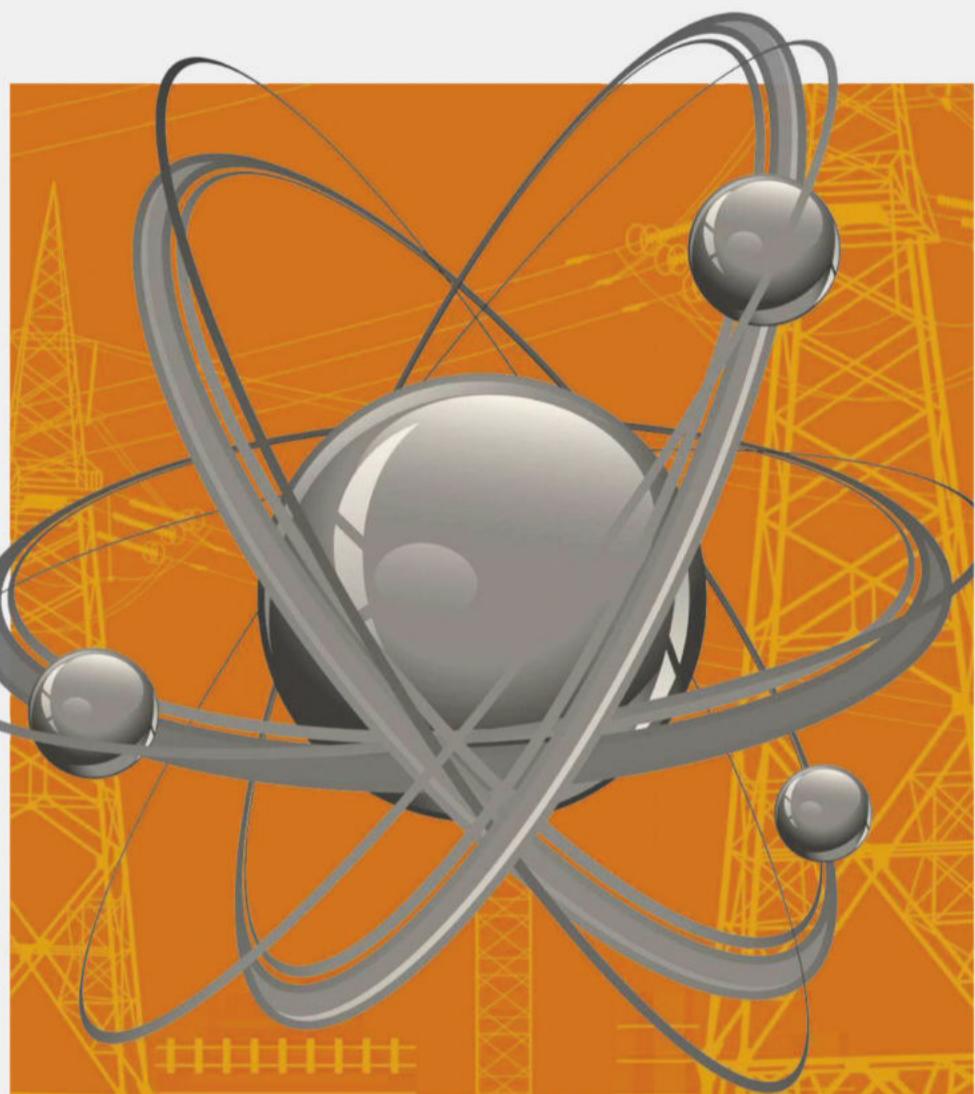
**PROF ROBERT MATTHEWS**  
Physicist,  
science writer



TOBY GRAHAM, SHREWSBURY

## HOW DO OCTOPUSES MOVE THEIR LIMBS IF THEY HAVE NO BONES?

Octopus arms work in a similar way to an elephant's trunk, a snail's foot and your tongue. Known as 'muscular hydrostats', these structures consist almost entirely of densely packed muscles. By combining in different arrangements, the muscles can provide an impressive range of movement. When octopuses crawl along the seabed, they contract lengthwise and crosswise muscles in their arms, elongating and shortening their arms in turn. They twist their arms by contracting sets of muscle fibres that wrap diagonally around them. HS



CHARLIE SIMMONS, LOS ALTOS HILLS, CALIFORNIA

## HOW CAN AN ELECTRON BE BOTH A PARTICLE AND A WAVE?

An electron is a tiny, negatively charged particle that whizzes round the atomic nucleus. That's been clear since its discovery by the British physicist J. J. Thomson in 1897. But 30 years later, his son George made a discovery. Sending electrons through a thin film of metal, he found that they created an interference pattern – just as if they were waves, not particles.

Like his father, George won a Nobel Prize for his work, but this 'wave-particle duality' – shown by all particles, including photons of light – still provokes arguments.

There are two schools of thought. One: particles change their nature depending on what happens to them. In some experiments, they become wave-like, in others particle-like. Two: they're weird things that always have a mix of both wave- and particle-like traits, but only reveal their wave-like aspects in some experiments, and their particle-like aspects in others.

So which is it? In 2012, two teams of researchers – one in France, the other in England – independently published the outcome of experiments capable of deciding between the two possibilities. Put simply, they let photons enter a device that would reveal their wave-like or particle-like nature – but the researchers could switch which of the photons' traits were probed. The results were consistent with the weirdest possibility: that they are both waves and particles all the time, and don't just change from being one to the other depending on what's done to them. Mindboggling – which is why many theorists suggest not thinking of electrons, photons and the like in everyday terms. Ultimately, they're members of the quantum world, and unlike anything familiar. **RM**



ADAM BATES, HALIFAX

## SHOULD I SQUEEZE MY TEABAGS?

Some tea aficionados insist that squeezing the teabag can release tannins, which makes the tea taste bitter. But there is nothing special about tannins that keeps them safely trapped in the bag until you squeeze it. Longer brewing times mean higher concentrations of all the flavour compounds, including tannins, which makes for a stronger cuppa. Squeezing just accelerates the process slightly because you don't need to wait for the molecules to diffuse out passively. Some teabags are actually sold with drawstrings, to make squeezing the bag even easier. **LV**



MARK BUCKMASTER, LEICESTER

## WHY HAVE TREES EVOLVED SUCH A VARIETY OF LEAF SHAPES?

Leaves have to do a lot more than just gather sunlight for photosynthesis. They also transport nutrients, take in carbon dioxide and oxygen, deter animals from eating them, and release water to cool the plant by evaporation, all while being sturdy enough to resist the physical battering of the wind and rain. That's a lot of different overlapping problems to solve at once, and every plant has a different set of priorities, according to the demands of its environment. Nevertheless, it's still remarkable how much the

leaves of the flowering plants and trees vary, when compared to the much more conservative designs of the conifers and ferns. Pelargoniums, which are popular houseplants, all belong to the same genus, but the different species have a huge variety of leaf shapes, from wispy fronds to broad heart shapes. Exactly how this happens is still a hot topic of research, but it seems that flowering plants have a few important structural genes that can cause dramatic changes to the leaf shape, with just minor genetic mutations. **LV**

# DIY SCIENCE

## SOAP-POWERED BOAT



### WHAT TO DO

1. Cut a 2cm by 3cm rectangle out of the milk bottle or carton so that you have a flat piece of material that floats on water. This is the 'boat', so feel free to make it more boat-shaped, as in our diagram!
2. Fill the tray with water.
3. Place the 'boat' on the water at one end of the tray.
4. Dip the matchstick (or cocktail stick) into the washing-up liquid.
5. Dip the soapy end of the matchstick into the water behind the back of the boat.
6. Watch as the boat speeds across the water.
7. The effect will stop working after a few goes. When this happens, simply change the water in the tray.

### WHAT'S HAPPENING

The key to this phenomenon is surface tension. Water molecules experience strong cohesive forces between one another, known as 'hydrogen bonds'. The molecules at the surface of the water don't have any water molecules above them, and so they bond even more strongly to the ones next to and beneath them. This extra-strong cohesion creates a kind of 'film' of high tension at the surface (this is what allows some insects to walk on water).

Washing-up liquid is known as a 'surfactant' because it weakens the hydrogen bonds and lowers the surface tension of the water. You can imagine the surface of the water as a web of molecules, each pulling on every other molecule around it. When the washing-up liquid is added and the bonds between the water molecules here slacken, the closest molecules experience a net force away from the point where the washing-up liquid is added, as they're 'pulled away' by the stronger bonds further away. The boat is sitting on the water, so it gets carried along by this movement of molecules. **AS**

## HIDDEN FIGURES

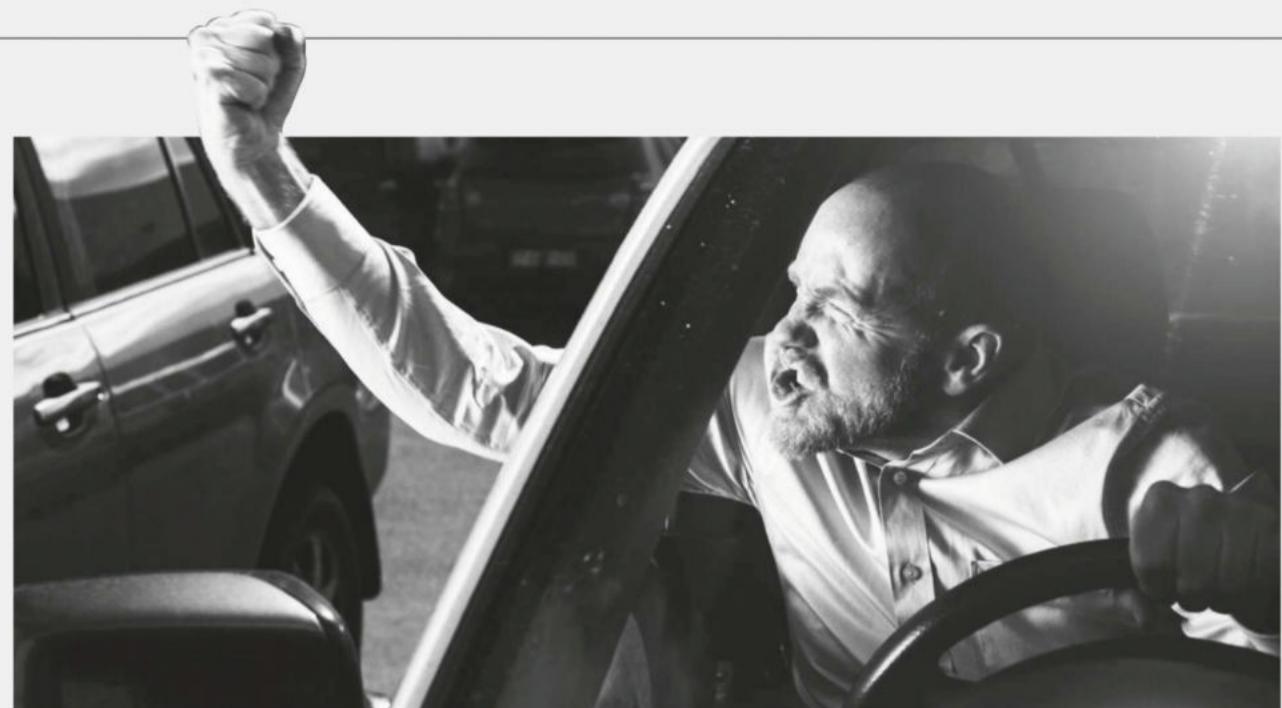
### CHIEN-SHIUNG WU THE 'QUEEN OF NUCLEAR RESEARCH'

In 1957, two physicists, Chen-Ning Yang and Tsung-Dao Lee, travelled from the US to Sweden to collect the Nobel Prize in Physics. They'd been proved correct about a bizarre feature of the 'weak nuclear force' – a fundamental force of nature affecting the atomic nucleus. Called 'parity non-conservation', it meant – roughly speaking – that the force could tell the difference between left and right.

But Yang and Lee hadn't proved it. Credit for that goes to another US-based Chinese scientist: Chien-Shiung Wu. But she never got invited to Sweden.

Born in Liuhe, China in 1912, Wu studied physics and then emigrated to the US, where she worked on the Manhattan Project to build the first atomic bomb. She then went to Columbia University, New York, becoming an expert on the weak force. In 1956, Lee and Yang asked if she could confirm their "crazy" idea. It was an incredibly difficult task, but within a year she'd designed and solved all the technical problems – and shown they were right.

Many physicists were shocked that her work was ignored by the Nobel Committee. One committee member later pointed out that her work was published after the deadline for being considered. But both Wu and others had a simpler explanation: sexism. *RM*



PAUL MELLOR, VIA EMAIL

## WHY DO PEOPLE BECOME AGGRESSIVE WHEN DRIVING?

The boundaries of the situation play a part – whereas a late-running pedestrian can walk more quickly, a driver often has no choice but to follow the speed of the car in front, or to give way to other vehicles. Compounding matters is the fact that we tend to be highly territorial about our cars – they're our own private space, and this is at odds with the fact that we're driving them in an often extremely busy public place. The role of territoriality in road rage was

confirmed by a 2008 study at Colorado State University, which found that people who put more effort into personalising their cars (with bumper stickers and such like – a sign of territoriality) were more prone to anger at the wheel. However, the idea that driving totally transforms our characters is an exaggeration. Many studies show that it's those who are generally more impulsive and aggressive in everyday life who are more inclined to road rage. *CJ*



BRIAN KIRKBY, VIA EMAIL

## ON AVERAGE, HOW MANY PLANETS ARE IN ORBIT AROUND EACH STAR?

Detection methods for finding exoplanets are somewhat biased towards exoplanets in particular orbital alignments, or which are close to their host stars, or which are very massive. So, depending on what statistical and physical assumptions are made, there are numerous estimates of the average number of planets around each star in our Galaxy. However, based on various studies, an average of between one and two exoplanets per star seems to be the most likely answer, giving as many as 400 billion planets in our Galaxy. *AGu*

## EXISTENTIAL FEAR OF THE MONTH...

### MY CAT ONLY LIKES ME FOR THE FOOD

Would it be so bad if this were the case? Acquiring nutrition is, after all, the daily struggle that all life on Earth faces. In fact, food is what first brought humans and cats together. Chemical analysis of the bones of 5,300-year-old cats from China has shown that these ancient felines were rodent-hunters that lived within grain stores. In essence, we gave them shelter and they took care of the pests.

As time passed, in Western cultures at least, house cats became selected for cuddles as well as their claws. And, from this point onwards, something deeper than cupboard love appears to have emerged. Just as with dogs, domestication of cats has unlocked a suite of kittenish

behaviours. These include grooming, play-fighting and bringing home half-dead mice for a spot of impromptu playtime. These behaviours are about more than food – they’re about family.

In September this year, scientists announced that cats appear to display traits of the “secure attachment” seen in dogs, where the presence of a human caregiver prompts behaviours signalling security and calmness. There’s even separate evidence that cats, upon receiving a stroke, get a sudden dose of brain hormones like we humans receive when around our loved ones. So perhaps now, canines have a rival in pursuit of the title of being humankind’s best friend. *JH*



GETTY IMAGES X4 ILLUSTRATION: DAN BRIGHT



NICK TUPPER, ALTON

### WHY DO MANY DOGS APPEAR TO HAVE AN INNATE FEAR OF BANGS?

Loud, unexpected bangs are frightening for most animals – including us. Loud noises generally mean a violent, high-energy event is nearby, so whether it’s a falling tree, a lightning strike or the roar of a large animal, loud tends to mean dangerous. Really loud bangs, like fireworks, are actually painful for dogs, since their hearing is so sensitive. But even more importantly, fireworks are an unexplained threat that appears to come from multiple directions at once. A 2015 study at Oslo University found that older dogs tend to be more scared of bangs, which suggests that rather than becoming desensitised, repeated exposure has the opposite effect. Some dog experts advise giving dogs treats or a special toy during thunderstorms and firework displays, so they learn to associate the bangs with a happy event. The Oslo study also found that noise sensitivity varies among breeds, with collies and schnauzers among the most fearful. *LV*

17

The altitude, in kilometres, to which ash and sulphur dioxide particles were blasted following the eruption of Russia’s Raikoke volcano in June. Light scattering on the particles caused purple sunrises and sunsets in certain regions of the world.



# DEAR DOCTOR...

## DELICATE ISSUES DEALT WITH BY SCIENCE FOCUS EXPERTS

### I LOVE WATCHING GORY HORROR FILMS. IS THERE SOMETHING WRONG WITH ME?

The history of cinema is full of unashamedly bloody films, and they're far from a niche interest: just look at the success of the *Saw* franchise. So if there's something wrong with you, there's something wrong with millions of other people, too.

The appeal of gory films lies in their ability to provoke visceral shock and excitement. Of course, not everyone gets a buzz from them: studies have shown that those who enjoy watching gore are more likely to score lower on empathy and higher on a personality trait known as 'sensation seeking'. Brain imaging research by psychologists at the University of Jena in Germany has shown

that sensation-seekers (such people also often enjoy fairground rides and dangerous sports) tend to have lower than usual neural activity levels when watching mild films, yet their brains are extra responsive to frightening or violent scenes, providing the stimulation that they crave.

One other thing: you didn't mention if you watch these movies on your own or with others. If you enjoy cuddling up on the sofa with your partner while watching, another possibility is that you love scary films because of the way they bring you closer together – what psychologists in the 1980s called the 'snuggle theory'. *CJ*



### MY CHILD HAS AN IMAGINARY FRIEND... SHOULD I BE WORRIED?



Once seen by psychologists as a sign of character weakness, or an inability to differentiate fantasy from reality, imaginary friends are today recognised as an entirely normal, and even beneficial, part of childhood (around half of all kids have one at some point). Imaginary friends can help children to make sense of the adult world and practise thinking about the emotional and mental states of others. They also allow kids to exercise their linguistic and storytelling skills, to feel comforted when lonely, and to feel competent and in control – by caring for their fantasy friend, for instance, or teaching them how to do things. So there's no need to worry! *CJ*

### I'M PREGNANT. WHY DOES MY MOUTH TASTE LIKE METAL?

Around 90 per cent of pregnant women experience changes in their sense of taste – sour or metallic tastes are most common. The effect is strongest in the first trimester, when oestrogen levels are rising fastest, but the exact cause is still unknown. Zinc deficiency has been blamed, but a 2009 study at Tokyo University found that zinc levels were normal in the first trimester. Another possibility is that the extra hormones affect bladder function. In 2006, researchers at Bristol University found that patients suffering from urine retention problems were more likely to experience odd tastes, and these symptoms vanished when the problem was treated. This may be because the regions of the brain responsible for taste and bladder control are very close together. *LV*

SONIA COOKE,  
NORTHAMPTON

### IS IT TRUE THAT THE PACIFIC AND ATLANTIC OCEANS DON'T MIX?

While we've given our planet's oceans separate names, in reality there's no border between them, and currents continually flow between them and mix their waters. The Atlantic and Pacific oceans 'meet' at the southernmost tip of South America. In this region, a strong current carries water from west to east, sweeping water from the Pacific into the Atlantic. The videos you may have seen online showing two different coloured bodies of water drifting alongside each other are actually showing light-coloured, sediment-rich freshwater from melted glaciers meeting dark, salty ocean water in the Gulf of Alaska (and over time, currents and eddies cause these to mix, too). *AFC*

IAN SILBERZWEIG, VIA EMAIL

## WHY DO PEOPLE HAVE DIFFERENT EYE SHAPES?

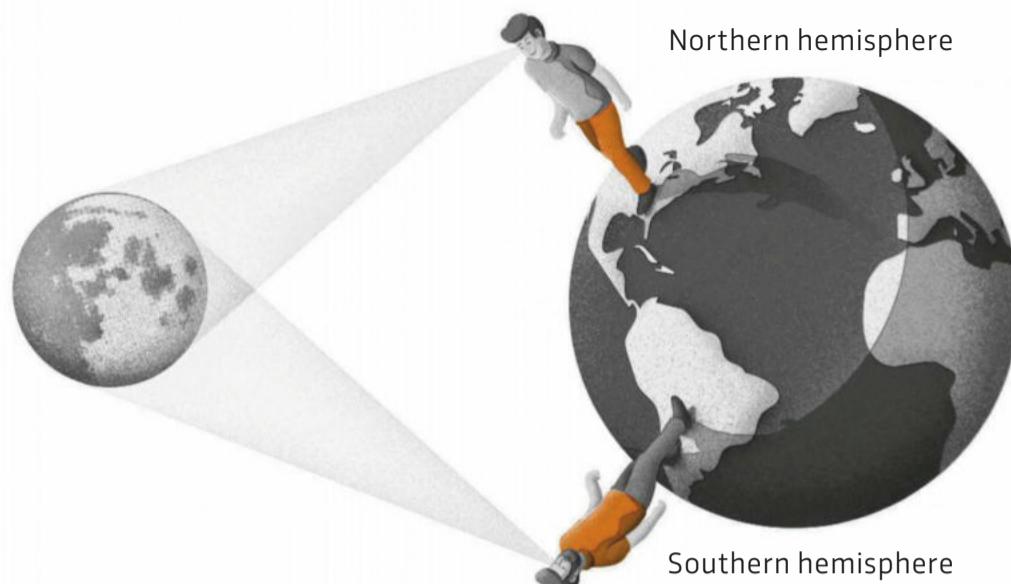
The main difference in eye shape is the way the upper eyelid meets the inner corner of the eye. In many ethnicities, including East Asians, Southeast Asians, Polynesians and Native Americans, there is commonly a slight fold at this point, called an 'epicanthic fold'. This is caused by fat deposits under the skin, and one theory is that it evolved to protect the eye against the cold, or against the stronger ultraviolet light found in snowy and desert environments. **LV**



KEN WANG, MANCHESTER

## WHY ARE LEMONS YELLOW AND LIMES GREEN?

All citrus fruits are green while they are still growing on the tree. Lemons lose their green colour as they ripen because the chlorophyll pigment is replaced with a chemical called anthocyanin. Many lime species would also turn yellow if you left them on the tree long enough, but they never get a chance. This is because ripe citrus fruits are too soft to travel well, so farmers always pick the fruits while they are green and under-ripe. Oranges and lemons will continue to ripen on their way to the supermarket, but a quirk of biology means that limes stop ripening once they are picked. **LV**



MILLIE GRANGER, LONDON

## DOES THE MOON LOOK 'UPSIDE DOWN' IN THE SOUTHERN HEMISPHERE?

Indeed, the Moon does look 'upside down' in the Southern Hemisphere compared to the northern hemisphere. This is simply a matter of orientation. Imagine if the Moon orbited in the same plane as the equator. If you were in the northern hemisphere, the Moon would always appear in the southern sky since that is the direction of the equator. The reverse is true in the southern hemisphere: the Moon would appear in the northern sky. So, these two observers are looking at the same object from opposite directions and naturally that means one sees the object flipped compared to the other. This means that the 'Man in the Moon' is upside down in the southern hemisphere, and can actually look more like a rabbit. **AGu**

## NATURE'S WEIRDEST CREATURES...

### THE BRAZILIAN TREEHOPPER

What has six legs and two pairs of balls? No, it's not the start of a lewd joke. It's the Brazilian treehopper, a pea-sized, rainforest-dwelling insect that sports a headdress worthy of a royal wedding.

The purpose of these bizarre, helicopter-like orbs – actually an elaborate 'pronotum' (an insect body segment just behind the head) – is still something of a mystery. Could they be an evolved structure like a peacock's tail, used by males to show off their genetic vigour to others? Unlikely: both males and females are endowed with balls, so to speak. Could they have evolved to look like a second 'dummy' head which predators mistakenly aim for when attacking? A lack of

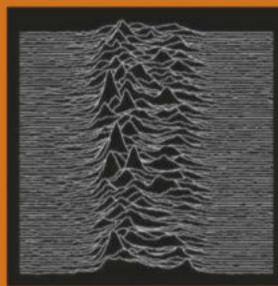
observations of this happening in the wild suggests not. Instead, insect scientists suspect that the structures evolved to mimic the handiwork of a parasitic fungus called *Ophiocordyceps unilateralis*, which invades the bodies of ants and then bursts *Alien*-style out of them, creating similar structures sprouting from the deceased insect. So the Brazilian treehopper is left alone because, well, no predator wants to risk accidentally eating the same fungus.

Though unusual among other insects, these ornate structures are a common feature among the 3,200 species of treehoppers, and can sometimes resemble thorns, leaves and even bird droppings. **JH**



## WHAT CONNECTS

### JOY DIVISION AND ALIENS?



1. Joy Division's seminal 1979 post-punk album *Unknown Pleasures* features a cover that is entirely black apart from a low-resolution mountainscape made up of 80 jagged white lines.

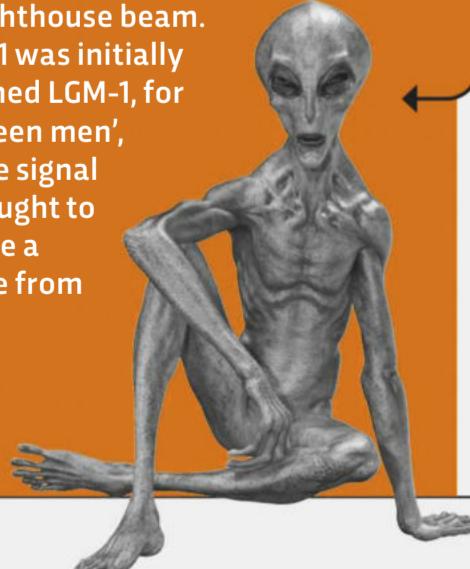


2. The lines are actually a graph showing the radio frequencies emitted from the pulsar B1919+21. This was the first pulsar ever discovered, and was found by Jocelyn Bell Burnell (pictured) in 1967.



3. A pulsar is formed when a star explodes in a supernova, leaving behind a rapidly rotating, ultra-dense core that has a magnetic field a trillion times more powerful than Earth's.

4. This magnetic field sweeps radio waves across the sky like a lighthouse beam. B1919+21 was initially nicknamed LGM-1, for 'little green men', since the signal was thought to resemble a message from aliens.



AARON, NOTTINGHAM

### IS SPARKLING WATER AS HYDRATING AS STILL WATER?

You'd think so, because it contains just as much H<sub>2</sub>O as the still variety. But in 2016, the journal *PLOS One* reported research from an international team of scientists showing that the 'fizziness' of such drinks tricks us into thinking we've drunk more than we have – meaning that we drink less and therefore end up less hydrated. **RM**



TERRY JENKINS, LONDON

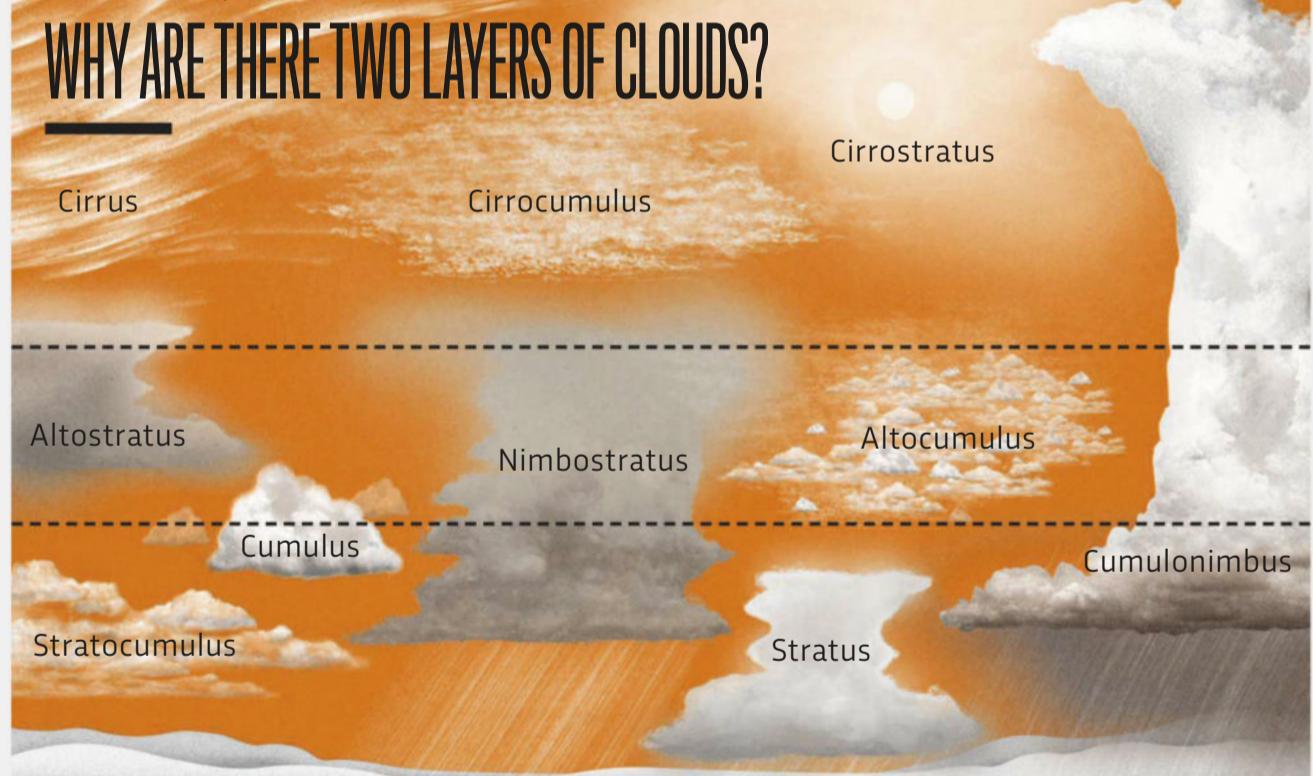
### HOW DO SMELLING SALTS WORK?

An incredibly pungent mix of ammonia, water and ethanol, smelling salts have been used since Roman times to revive people who have fainted. They're also used in some sports in an attempt to boost performance: many American football players believe they're an effective stimulant. But a review published in the *British Journal Of Sports Medicine* in 2006 concluded that smelling salts work because the fumes irritate the membranes in the nose and lungs, triggering a sharp intake of breath – but there is no lasting benefit. **RM**



SHIRI KLEINBERG, LONDON

### WHY ARE THERE TWO LAYERS OF CLOUDS?



A cloud is born when humid air rises in the atmosphere. As temperature and pressure drop, water vapour carried in the air condenses into tiny water droplets or ice crystals to create a cloud. The height at which a cloud forms depends on the temperature and pressure of the air, as well as how much water it contains. The World Meteorological Organization classifies clouds into three broad categories according to altitude, but there is considerable overlap as clouds can be very tall. Clouds whose

bases lie at altitudes below 2km are considered low-level clouds. These are formed of mostly liquid water droplets, with common types including 'cotton wool' cumulus and featureless, sheet-like stratus. Mid-level clouds sit between roughly 2km and 7km and include vast blankets of altostratus or clumpy altocumulus. (Their water can be liquid or ice depending on the altitude.) High-level clouds have a base above 5km and are made of ice crystals, giving rise to thin, translucent clouds like wispy cirrus. **AFC**



RACHEL HARRIS, BRISTOL

## WHY IS BLACK PLASTIC SO DIFFICULT TO RECYCLE?

The plastic itself is usually recyclable; the problem is the colouring. Most black plastic is pigmented using carbon. This is cheap, food-safe and provides a deep, uniform black. But as well as absorbing visible light, it also absorbs the near-infrared part of the spectrum, which has the unfortunate side-effect of making it invisible to the sorting machinery at recycling plants, which uses infrared beams to sort materials by colour and material. The stealthy black plastic thus passes undetected into the 'miscellaneous' bin at the end of the conveyor, which is destined for landfill. Charities like the Waste and Resources Action Programme (WRAP) are working with manufacturers in the UK to develop alternative black pigments that will allow black plastic to be recycled. **LV**



JOSEPH WOOD, OXFORD

## WHY DO SO MANY AMERICANS DRIVE AUTOMATIC CARS?

Automatic cars in the US are generally cheaper, more powerful, and are used to drive long distances on relatively straight roads. Europe is more densely populated and its old roads are small, bendy and require more anticipation, so manual gears allow the driver to be more reactive, selecting the right gear at the right time. American driving can also involve a lot of stopping and starting: stop signs tend to be used in place of roundabouts, so manual gear changes become a nuisance. **PB**

## QUESTION OF THE MONTH



TAMSIN NICHOLSON, WARWICKSHIRE

## WHY ARE THERE SO MANY SPECIES OF BAT?

There are more than 1,200 bat species in the world, accounting for almost a fifth of all mammal species. Part of the reason for this is that bats are the only mammals with flapping flight, which means that bat colonies can travel long distances and become geographically isolated from each other, splitting into separate species. But a 2011 study at the University of Massachusetts suggested that their diversity might also be because the diets of different bat species tend to be highly specialised. This means that if a genetic mutation causes, for example, a small change in the shape of the skull or the bite force of the jaw, a bat might be able to eat a new type of fruit or insect that other bats in the area can't handle. This gives a big selective advantage to the descendants of this bat, and the

mutation spreads. Within an evolutionary short time, the population has split into two groups and another bat species is born. **LV**

### WINNER

Tamsin wins a Minut Point smart home alarm, worth £129! The Minut Point is easy to install and allows you to keep an eye on your home, using the accompanying app. Plus, it gives notifications of potential threats by monitoring changes in temperature, motion and sound. [minut.com](http://minut.com)



EMAIL YOUR QUESTIONS TO [QUESTIONS@SCIENCEFOCUS.COM](mailto:QUESTIONS@SCIENCEFOCUS.COM) OR TWEET US @SCIENCEFOCUSQA

# RADAR

WHAT'S LIGHTING UP OUR ANTENNA THIS MONTH

## Bill of health

We sit down for a chat with Bill Bryson about his new book *The Body* p100

## Sir David is back

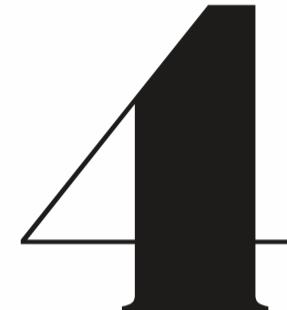
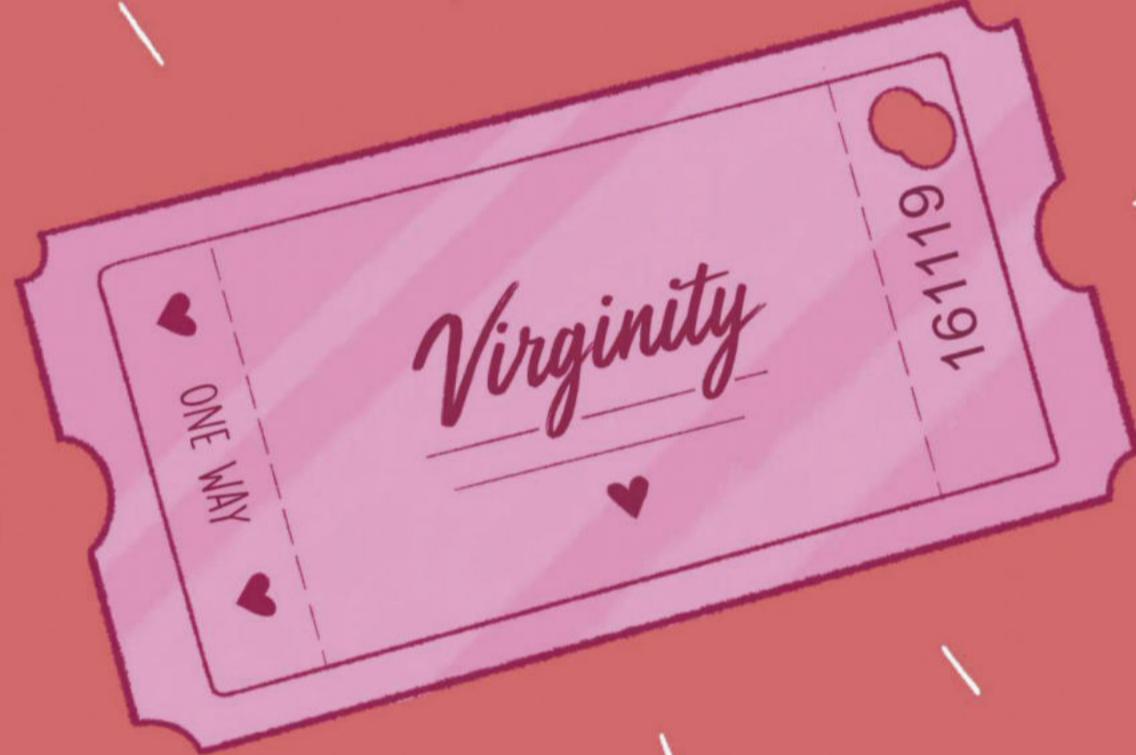
David Attenborough's *Seven Worlds, One Planet* debuts this month p102

## Reading list

Curl up with our choice of this month's best science-y books p102

## Books that made me

Science and environmental writer Gaia Vince reveals her favourite books p103



1

## MUFF BUSTERS: VAGINA MYTHS AND HOW TO FIGHT THEM

**The Vagina Museum, Camden Market, London**

**The museum, thought to be the first of its kind in the world, is home to various vagina-related workshops, events and film screenings this autumn. Exploring popular misconceptions about gynaecological anatomy, *Muff Busters* is the museum's first exhibition.**

**From 16 November**



2

## SCIENCE SPEAKEASY

**Newcastle University**

Sperm counts have been declining for decades, so why are all our conversations around fertility centred on women?

**7pm, 14 November**

3

## ALCOHOL AWARENESS WEEK

Get thinking about drinking! Visit the campaign website to quiz yourself – how much do you *really* know about your own drinking habits (be honest!), and what effects might your alcohol consumption be having on your mental and physical wellbeing?

**11-17 November**

[alcoholchange.org.uk](http://alcoholchange.org.uk)



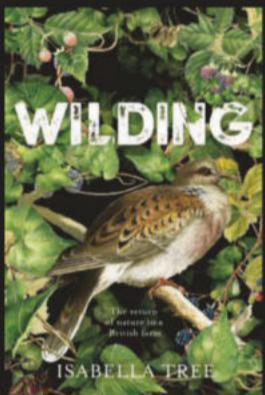
## NANOMATERIALS FROM BENCH TO BEDSIDE

**The Royal Society, London**

Since 2003, the Rosalind Franklin Award has been given to women for achievements in any science, technology, engineering or mathematics field. This year's winner is Prof Nguyễn Thị Kim Thanh (below), who will be giving a lecture on her work with nanomaterials.

**6pm, 29 October**

## 5



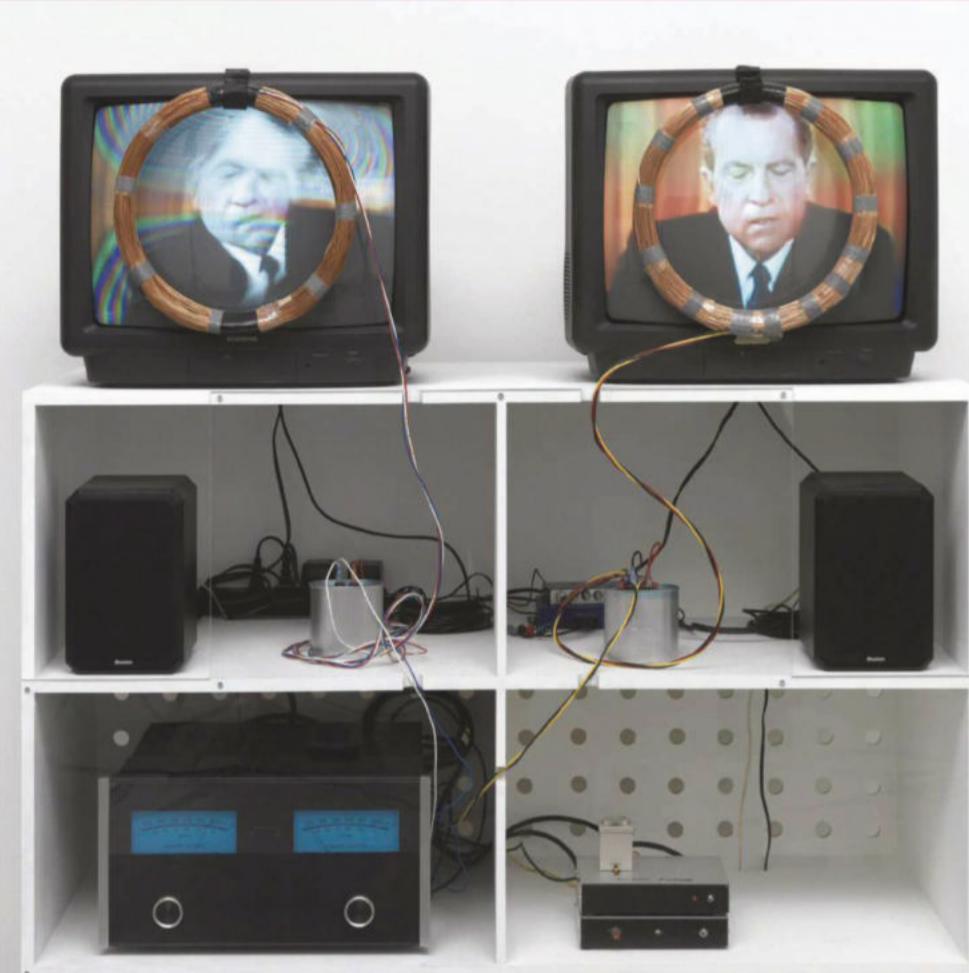
## REWILDING: IS IT THE FUTURE FOR BRITAIN?

Royal Albert Memorial Museum, Exeter

Join Martin Wright, chair of the magazine *Positive News*, in conversation with naturalist Dan Eatherley and writer Isabella Tree, who is also leader of a rewilding project at Knepp in Sussex.

3pm, 10 November

Tickets available at [exelitfest.com](http://exelitfest.com)



## 6

## NAM JUNE PAIK

Tate Modern, London

Combining art and technology, Korean-American Nam June Paik collaborated with engineers, composers and artists in a five-decade-long career. He is attributed with coining the phrase 'electronic superhighway' after predicting the power of the internet. This major exhibition at the Tate Modern showcases over 200 items from his life's work.

Until 9 February

## 7

FOR THE FAMILY

## PLAY WELL

Wellcome Collection, London

Is playing really important? The new exhibit at the Wellcome Collection explores how play has transformed our society. From children's toys to video games and comic strips, *Play Well* shows how our innate desire to play has benefited us over the years.

24 October – 8 March



## 8



## RICHMOND LITERATURE FESTIVAL

Richmond upon Thames

This festival offers a range of talks and events. Our picks include an evening with mental health nurse Nathan Filer and psychiatrist Joanna Cannon (pictured left), both bestselling authors in their own right. For families (and fossil enthusiasts) author Anthea Simmons will be telling the story of Mary Anning, the 19th-Century scientist who defied gender stereotypes to discover fossils.

1–24 November

Tickets available at [richmondliterature.com](http://richmondliterature.com)

**Profile**

# BRYSON ON THE BODY

**BILL BRYSON IS KNOWN FOR HIS TRAVELOGUES AS WELL AS POPULAR SCIENCE BESTSELLER *A SHORT HISTORY OF NEARLY EVERYTHING*. NOW, IN *THE BODY*, HE LOOKS AT THE MECHANISMS THAT KEEP US ALL ALIVE**

**YOUR PREVIOUS BOOKS HAVE BEEN INSPIRED BY YOUR OWN EXPERIENCES. WAS THERE ANYTHING THAT INSPIRED YOU TO WRITE *THE BODY*?**

One thing was this nagging realisation that I knew nothing at all about what goes on inside me. You know, I've been spending six and a half decades or so just throwing beer and pizza down my throat and yet here I am, still upright and generally in pretty good health.

At the same time, my oldest son was at medical school and he would talk with great enthusiasm about the things he was learning. I was kind of captivated by his interest and felt like I really ought to try to know a bit more about [the body]. But then I also discovered that, although he knows everything you need to know about the body in order to practise medicine, he knew and was taught very little about the social history of the body.

I could say to him, "Why is it called Parkinson's?" And he wouldn't know. I mean, he'd know everything you need to know in order to treat Parkinson's disease, but he wouldn't know the story of the original Parkinson, or Alzheimer, or lots of

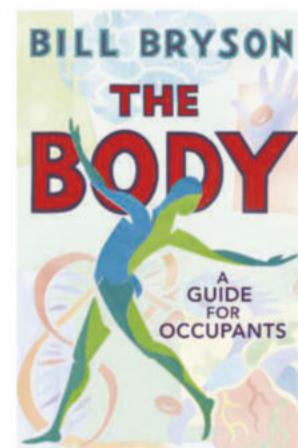


**"The thing that came across to me really powerfully in the book was just how lucky we are to have life"**

other things. So I realised that even for people who learn about the body at a very technical level, there's a great deal that they usually don't know, because they don't get the cultural and social side of these things.

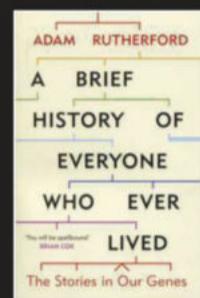
**AND *THE BODY* IS NOT JUST A STUDY OF OUR BODIES, BUT OF THE PEOPLE WHO HAVE STUDIED AND LOOKED INTO THE BODY, ISN'T IT?**

That's, to me, the really fascinating thing. And it was the same thing with my other book, *A Short History Of Nearly Everything*. What really fascinated me as I got more and more into the research wasn't just what we know, but how we know what we know. I have no



**THE BODY**  
BILL BRYSON  
(£25, TRANSWORLD)

## AUTHOR'S BOOKSHELF

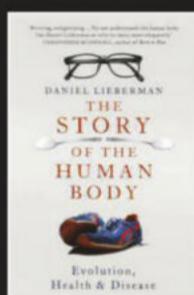


### A BRIEF HISTORY OF EVERYONE WHO EVER LIVED

ADAM RUTHERFORD

(£9.99, WEIDENFELD & NICOLSON)

An excellent book that I definitely recommend. I referred to it a lot in my own research.

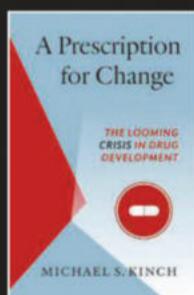


### THE STORY OF THE HUMAN BODY

DANIEL LIEBERMAN

(£9.99, PENGUIN)

Much more technical. When I needed to know the real science behind things to do with the body, this was the book I turned to.



### A PRESCRIPTION FOR CHANGE

MICHAEL KINCH

(£24.58, UNIVERSITY OF NORTH CAROLINA PRESS)

This is about all the problems we're going to have with not getting enough new antibiotics into the market. Quite a scary book, but an important one.

aptitude to be a scientist or a researcher who figures these things out. So I'm fascinated by people who can do it, and just full of admiration for them.

Almost everything we know in any field of science, the body not least, it's because of lots and lots of people doing very specific technical work. I like to think of myself as friends with Venkatraman Ramakrishnan who's the president of The Royal Society. He's a wonderful guy and he got a Nobel Prize, but he spent his whole life just looking at ribosomes. I couldn't do that. I wouldn't have that sort of application. Of course, by doing that, he learns a little bit more about how the cell works, and you add that to all the other people who are doing lots of other things around the world, and you get, in the end, a huge amount of knowledge.

You know, the world of science is not just Einsteins and Newtons: it's also lots of people who don't get a great deal of attention because they work in very arcane and specific areas. I couldn't spend my whole life just studying snails or lichen, or something like that. It's a very lucky thing that there's people in the world who can do that, but for me, I'm much more of a magpie. I flit around from place to place and thing to thing.

### DO YOU HAVE A NEW APPRECIATION OF YOUR BODY AFTER RESEARCHING IT FOR FOUR YEARS?

Yeah, I do: not just for my body but for life altogether. The thing that came across to me really powerfully in the book, a bit unexpectedly, was just how lucky we are to have life. I don't know if this is from doing the book, or just because I'm 67 years old and moving towards the end of my time on Earth. But you realise that life is very precious.

You didn't exist for a long time before you were born, and when you die, you're not going to exist ever again. So every life is just this little, brief spell in the middle of a great, massive eternity. And so I really feel quite profoundly – even more so now, having done the book – that none of us should let a day go by when we don't just revel in the fact that we get to have existence.

### YOU'VE HAD AN AMAZING CAREER AS A PROLIFIC WRITER. WHAT HAS BEEN THE HIGHLIGHT?

Oh gosh. That's impossible to say really. I've had just the happiest, luckiest career. If you're

lucky enough to be successful, you really are very, very lucky. It's like winning the lottery.

I think it was a lot easier to build up a career little by little when I started, really in the 1980s, than it is now. It's a much tougher business than it used to be. So I'm very, very lucky to have gone through it when I did, and I feel kind of glad to be coming to the end of my career now rather than at the beginning.

### DO YOU CONSIDER YOURSELF TO BE AT THE END OF YOUR CAREER NOW, THEN?

Yeah, absolutely... and very happy about it. Writing has been a great pleasure to me, but it's hard work.

I'm not saying I'm retiring 100 per cent, but I would really like to take a lot more time off and do things like travel with my wife. She, poor woman, stayed at home and raised four kids while I was off having this fantastic life as a travel writer and journalist for many years. So what I've been trying to do – little by little, now that our kids have grown up – is take her to some of the places I really enjoyed going when I was writing more actively.

There's still lots of places I've not been at all, or have barely been. One place I'd love to go back is to Japan, and I've never been to Russia or India. But having said that, my wife is keen to not do a lot of long-haul travel, and it would clearly be better for the Universe and the world if we all cut back.

So I think we'll focus more on just travelling within Britain. There's still an infinite number of things to see here.



### BILL BRYSON

Bill is a world-renowned travel writer and science communicator, and in 2006 was made an honorary Officer of the Order of the British Empire (OBE) for his contribution to literature.

Interviewed by BBC Science Focus editorial assistant Amy Barrett.

### DISCOVER MORE

 Subscribe to the Science Focus podcast and listen to our full interview with Bill Bryson in an upcoming episode. [sciencefocus.com/science-focus-podcast](http://sciencefocus.com/science-focus-podcast)

# RECOMMENDED

WHAT'S CAUGHT OUR ATTENTION THIS MONTH



by **Amy Barrett**

EDITORIAL ASSISTANT

**A**s the clocks go back, it's time to line up some winter tonics: a good TV show to watch on cold nights, something to keep me awake on my dusky commute, and perhaps an event just enticing enough to get me to leave my cosy pyjamas and venture outside.

This month, I'll be rushing home to watch *Seven Worlds, One Planet* on BBC One. Sir David Attenborough returns to narrate an exploration of the seven continents that make up our planet, starting in episode one with the white wonder that is Antarctica.

To distract from the howling winds, I'll be popping in my earphones to listen to psychologist Dean Burnett's new book, *Psycho-Logical*. It examines the latest research to piece together what goes on in our brains when we experience and need treatment for serious mental health problems. It's exclusive to Audible, so you'll need a membership (or a free trial).

And I'll also be trying out Apple's new gaming service, **Arcade**. For £4.99 a month, Apple devices get unlimited gaming across devices, plus access to Arcade-only games such as *LEGO Brawls* and the hugely addictive *Hexaflip*, which will have you furiously tapping left, right, left, left, right to hop from hexagon to hexagon at any opportunity.

The one thing guaranteed to get me out of the house this month is **TRON-FEST**. On 2 November at Bristol University, the team behind the *Cosmic Shed* podcast will be screening the 1982 sci-fi classic, *Tron*, and its 2010 sequel, after which psychologist Pete Etchells will discuss video games, futuristic tech and CGI. Profits from the event go to Special Effect, which campaigns to make video games more accessible for disabled people.



**“David Attenborough returns to narrate an exploration of the seven continents that make up our planet, starting in episode one with Antarctica”**



# READING LIST

WHAT TO PUT ON YOUR BOOKSHELF

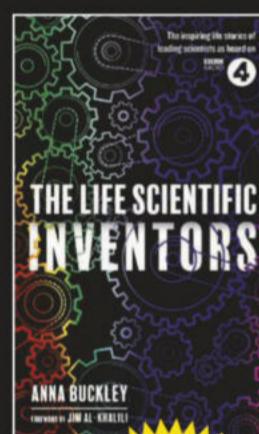


## THE CROWD AND THE COSMOS: ADVENTURES IN THE ZOONIVERSE

CHRIS LINTOTT

£20, OXFORD UNIVERSITY PRESS

Anyone can get involved with citizen science projects like those listed on the Zooniverse website, and *The Sky At Night* presenter and Zooniverse creator Chris Lintott's book tells you how 10 minutes of your time can lead to big discoveries. Subscribe to the *Science Focus Podcast* to hear our interview with Chris.

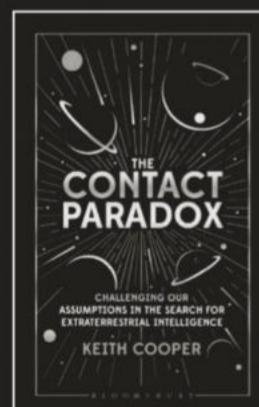


## THE LIFE SCIENTIFIC: INVENTORS

ANNA BUCKLEY

£18.99, WEIDENFELD & NICOLSON

The BBC Radio 4 series celebrates its 200th episode this month. In this book, series producer Anna Buckley collects the stories of 'unsung' inventors who have helped shape our modern world. *The Life Scientific: Inventors* celebrates the mathematicians, mechanics, engineers and entrepreneur who've contributed more to our daily lives than most of us probably realise.



## THE CONTACT PARADOX

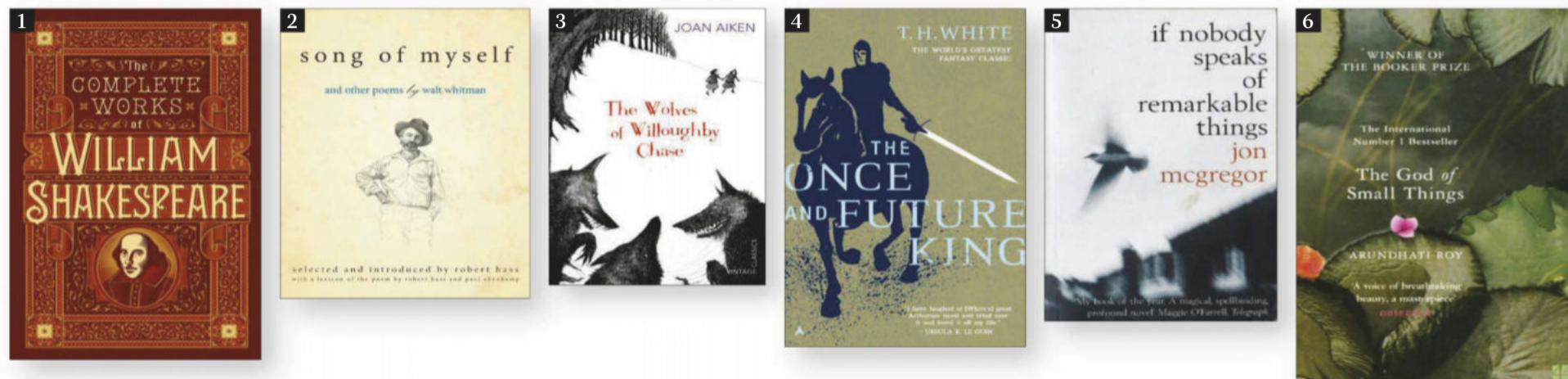
KEITH COOPER

£16.99, BLOOMSBURY SIGMA

How close are we to finding extraterrestrial life? *The Contact Paradox* tells the story of the Search for Extraterrestrial Intelligence (SETI) Institute, a non-profit scientific research centre in California where researchers search the 100 billion stars in our Galaxy for signs of life. Keith Cooper, editor of *Astronomy Now*, reveals how technology is used at the SETI Institute to search for life.

# THE BOOKS THAT MADE ME: GAIA VINCE

SCIENCE JOURNALIST AND AWARD-WINNING AUTHOR **GAIA VINCE'S** SECOND BOOK, *TRANSCENDENCE*, IS PUBLISHED THIS MONTH. HERE, SHE TELLS US ABOUT THE BOOKS THAT SHE'D TAKE WITH HER IF SHE WAS CASTAWAY TO A DESERT ISLAND...



If I was picking the books that I genuinely wanted to read over and over again, they would be all poetry books. They are the only books I re-read constantly. I'd be given *The Complete Works Of Shakespeare*, because that's what guests on *Desert Island Discs* are given. Even if you didn't give them to me, I'd still choose them – they're brilliant to read over and over. The tragedies, the comedies... they're brilliant. They're timeless.

To pick just one piece of poetry, I'd choose *Walt Whitman, Song Of Myself* (1855), because it's so life-affirming. That's what I'd read, if I wanted to be uplifted and encouraged in a solitary situation.

As a child I would re-read books. I think when you're a kid, books mean a lot more to you. They become really personal. One of the books that really changed me, I think, was *The Wolves Of Willoughby Chase* (1962), by Joan Aiken. It's a fantasy set in Britain, and it's kind of historic, but it also feels very real. It was scary but it was exciting, and it was just escapism for me. I loved that story.

T. H. White's *The Once And Future King* (1958) is beautifully written and made a big impression on me when I read it. That was when I was older. It's about King Arthur, and was just so exciting and unlike the drudgery of my South London life. Kings, queens, magic. Also, it was really kind of, for me, racy. I don't know if it was, actually; I haven't read it since I was younger. Perhaps it's not racy at all. But when I was a kid, my God, I don't think I got half of it.

When I was in my 20s, as a student, *If Nobody Speaks Of Remarkable Things* (2002) by Jon McGregor

was a really, really important book for me. It felt like it was speaking about exactly my situation, although I wasn't like any of the characters in it. I was living in a bedsit in Greenwich with no money, doing odd jobs between courses, not really sure where I was going in life. That was a book very much about that, in a way. Nothing really happening, and yet everything happening under the surface.

*The God Of Small Things* (1997) by Arundhati Roy is another incredible book. It's basically about how tiny little things make a huge difference and can completely change people's lives. How interconnected we are and how seemingly small events can have huge repercussions. It's about relationships between people which is, for me, the most interesting thing in a book, always



**“How interconnected we are and how small events can have huge repercussions. It's about relationships between people which is, for me, the most interesting thing in a book, always”**



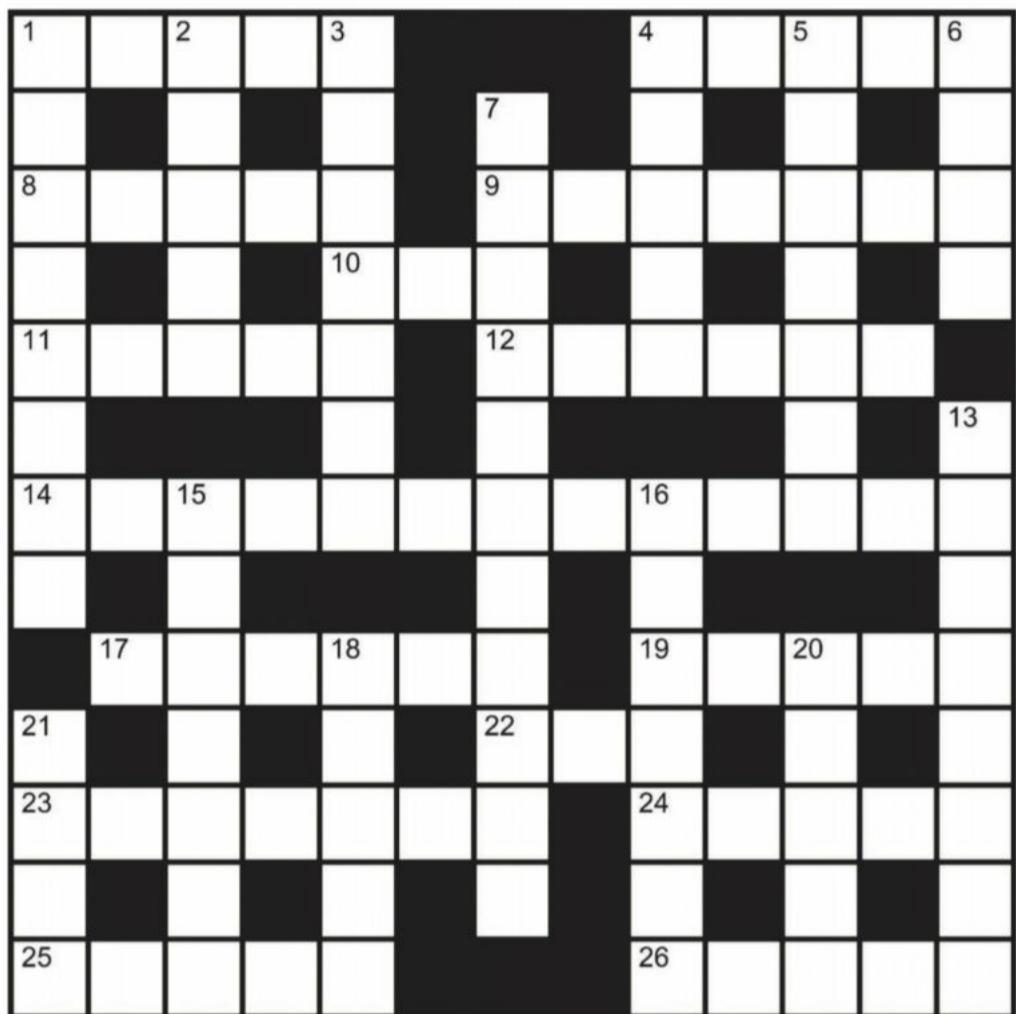
by **GAIA VINCE** (@WanderingGaia)  
Gaia is a freelance science and environment writer. Her latest book is *Transcendence*, out on 7 November.



**TRANSCENDENCE**  
GAIA VINCE  
 (£20, ALLEN LANE)

# CROSSWORD

## GIVE YOUR BRAIN A WORKOUT



### ACROSS

- 1 Quagmire was sorted out by politician (5)
- 4 Feast arranged for Clotho and the others (5)
- 8 Fast old tempo (5)
- 9 Sharp change of direction for top stylist (7)
- 10 Greek character of deep sincerity (3)
- 11 Virginia has log transported in river (5)
- 12 Nurse with functioning hamstring (6)
- 14 Rush to terribly scenic Spain – that's a difficult subject (6,7)
- 17 Quiet word with graduate on island city (6)
- 19 Break arm – asymmetrically, for luck (5)
- 22 Tease something in cage (3)
- 23 Ruin a pitch with a bit of bread (7)
- 24 The French dog went mad in gatehouse (5)
- 25 Timber has width to adjust (5)
- 26 Moving north? That's sharp (5)

### DOWN

- 1 Lisa managed to change, like a gland (8)
- 2 Void shaped like a ring, after last couple left (5)
- 3 Support an energy fuel (7)
- 4 Pretend to mix gin after iron (5)
- 5 Mistake about Henry taking on storm (7)
- 6 Reported gesture provides mathematical function (4)
- 7 Solvent, having spotless character (5,6)
- 13 Maybe whale notes in strange accent (8)
- 15 Coarse as returning in campaign (7)
- 16 Forced to blink in psychoanalytical test (7)
- 18 Gloomy and stern with student (5)
- 20 Raid carried out by old medium (5)
- 21 Posed with Catholic singing style (4)

GETTY IMAGES

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# RISE AND SHINE

IN THE MORNING, DO YOU CRAVE A BIG FRY-UP, OR PREFER TO JUST RUN OUT OF THE DOOR? WE GET THE COFFEE BREWING AND TALK ABOUT BREAKFAST WITH NUTRITIONIST **LEONIE RUDDICK-COLLINS**



## IS BREAKFAST REALLY THE MOST IMPORTANT MEAL OF THE DAY?

Despite the media hype, the benefits are not as obvious as you might think. There's no clear-cut link, for example, between breakfast and body weight, blood pressure or cholesterol. That said, studies have shown that having breakfast can help concentration and memory, and it also plays a key role in blood glucose regulation.

## IS IT POSSIBLE TO HAVE A HEALTHY FRY-UP?

Absolutely. It's about how you cook it. Use a healthy oil, or grill it, and don't go overboard on portion size. A bit of bacon every now and then is fine, just remove as much fat as you can. Baked beans are fantastic in the morning, so are eggs, mushrooms and tomatoes.

## WHAT CEREAL SHOULD I PICK?

Many breakfast cereals are laden with sugar. For some, sugar makes up more than a third of the total content. Look carefully at the labels. A low-sugar product contains less than 5g of sugar per 100g. Go for low-sugar, fibre-filled cereals, like Weetabix, oats and bran flakes. Be aware that although it's healthy, muesli is calorie-dense, so watch the portion size. Have a small bowlful with yoghurt, to help you get the right balance of fibre, iron and calcium.

## TEA OR JUICE?

Go easy on the fruit juice. Many juices contain the same amount of sugar as cola, but we don't realise this. My advice is to go for tea and a piece of fruit, like an orange.

## IS IT TRUE THAT BREAKFAST KICK-STARTS YOUR METABOLISM?

People cite this as a reason why we should eat breakfast but it's not exactly true. Metabolism increases naturally when you get up in the morning and after you eat any meal. It doesn't have to be breakfast.

## SHOULD I BREAKFAST LIKE A KING AND DINE LIKE A PAUPER, AS THE OLD ADAGE GOES?

The typical UK style of eating is to consume 48 per cent of your calories at dinner, and just 16 per cent at breakfast, but studies suggest that if we eat more in the morning, and less later in the day, it can help with weight loss. This makes sense because the body is primed to eat early in the morning to give us energy to get through the day. In the evening, the body prepares itself for an overnight fast. It breaks down its stored energy, like fat and glucose, to use as fuel while we sleep. Late eating may interfere with this process. So, if you're trying to lose weight, maybe a bigger breakfast is the way to go.

## IS SKIPPING BREAKFAST BAD FOR YOU?

It's not great. Skipping breakfast has been linked to an increased risk of type 2 diabetes. This could be because breakfast skippers tend to eat more later in the day when our bodies are more glucose intolerant.

Also, compared with breakfast eaters, people who skip breakfast tend to be lacking in key nutrients, such as fibre, iron and calcium. These are the sorts of things that are frequently found in breakfast foods, so the morning meal is an ideal opportunity to stock up on them. **SF**

## NEED TO KNOW...

1

Read the labels of cereals, and check portion sizes.

2

If you love a fry-up, use healthy oils and fill up on tomatoes, baked beans, mushrooms and eggs.

3

DR LEONIE RUDDICK-COLLINS

Leonie is a nutrition researcher at the Rowett Institute in Aberdeen.

Interviewed by Dr Helen Pilcher.

Your mum was right – it's good to breakfast like a king.

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